POWER PLANT ENGINEERING

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Power Plant for General Electric Company Erie Works

NATURAL LIGHT AND VENTILATION, COMPLETE MECHANICAL COAL AND ASH HANDLING EQUIPMENT, EXTRACTION TURBINES AND SPRAY POND ARE FEATURES OF THIS NEW PLANT

AT THE ERIE, PA., WORKS of the General Electric Co. the power, light, heat and compressed air problems have been solved by providing what in essentials is a central station. Yet the choice of equipment was governed somewhat by the heating and manufacturing requirements which makes the problem considerably different from that of designing a central power station. The works are some 4500 ft. from the shore of Lake Erie and about 75 ft. above surface level of the Lake and although a plant at the Lake shore was considered, where condensing water could be obtained without much expense, the engineers chose a location nearer the center of the load as more desirable largely on account of the loss which would be met in transmitting by-product heat from the Lake shore to the works.

The present plant represents only about one-fourth the capacity of what may eventually be the demands placed upon it, so that the plant is built with the idea of extending the buildings to house needed equipment as the demands grow up to the point of providing 250,000 lb. of exhaust steam per hour and a power output of 25,000 kw.

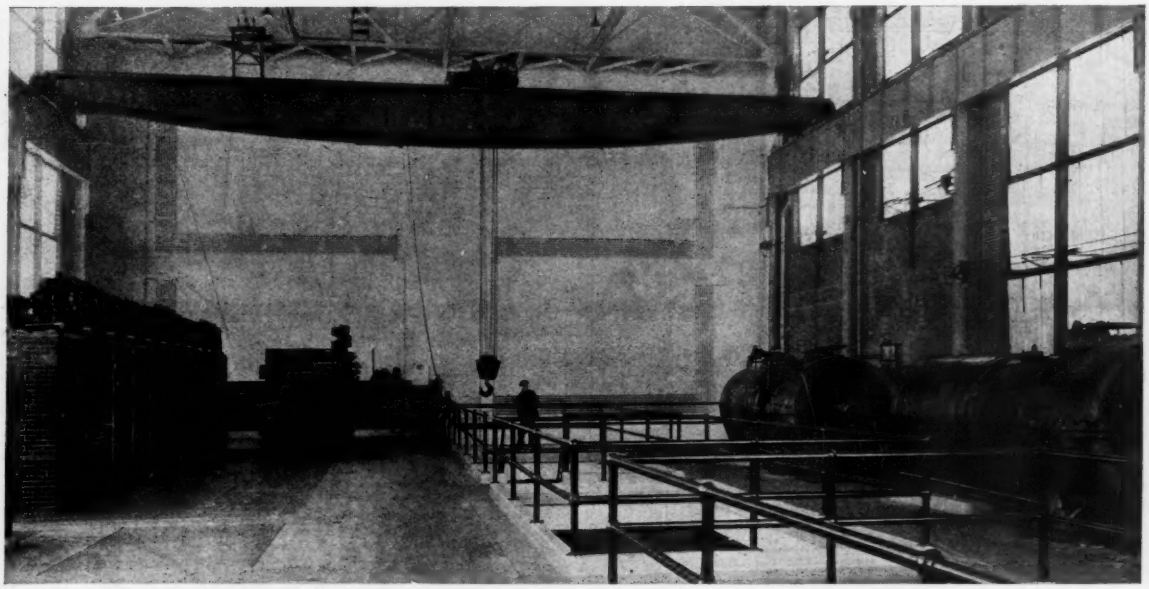


FIG. 7. GENERAL VIEW IN TURBINE ROOM

COAL AND ASH HANDLING

HANDLING OF coal and ash in a power plant of this size is one of the most important items to be considered and a very complete system has been worked out here for doing this entire work mechanically. In the basement of the boiler house, as will be noted in illustrations, are three full-sized railway tracks running the entire length of the plant. Beneath these tracks is coal storage space sufficient for holding two days' supply or twenty-one 50-ton cars. Normally the center track only will be used for coal and the other two for ashes, but in winter the cars loaded with coal may be run in on these tracks and left standing until they are thawed out then dumped directly to storage. This provision will at times save demurrage charges.

It is planned that coal coming to the plant should be dumped into a track hopper of approximately 50 tons

capacity which discharges through a crusher to a belt conveyor which delivers to a bucket elevator. The elevator carries the coal to the top of the boiler plant and discharges to another belt conveying system for delivery to the boiler bunkers located over the firing aisles.

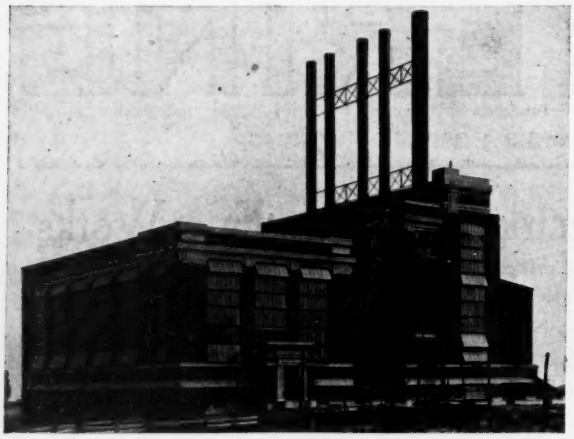


FIG. 1. NATURAL LIGHTING AND VENTILATING FACILITIES ARE INDICATED IN THE EXTERIOR VIEW OF THE CENTRAL POWER STATION FROM THE SOUTHWEST

These bunkers have a capacity of 150 tons to each boiler which is estimated to be sufficient for 2½ da. run.

For reclaiming the coal from the low storage, also for unloading flat-bottom cars, a crane is provided in the basement which travels over the middle track only.

The ash hoppers into which the stokers dump are of sufficient size to hold the accumulation of a 24-hr. run and each day the ashes are discharged directly in railway cars and removed for disposal. At present, the ashes are used for filling purposes about the plant.

Features of the Boilers and Furnaces

At present six boilers are installed, but provisions are made for six more of the same size with plans for doubling that equipment as need arises. These boilers are of the horizontal, three-drum water-tube type with a rating of 600 hp. each; the working pressure is 200 lb. per sq. in. and the steam is superheated 50 deg. F. Under present conditions, the boilers are worked regularly at about 200 per cent of their rated capacities with an occasional peak load of 300 per cent for a duration of 2 to 3 hr.

The boilers are placed two in one setting with a stack for each boiler, but in the final arrangement the 12 boilers will deliver through economizers to one stack. The flue gas temperature, a record of which is kept by a recording thermometer, averages 525 deg. F.

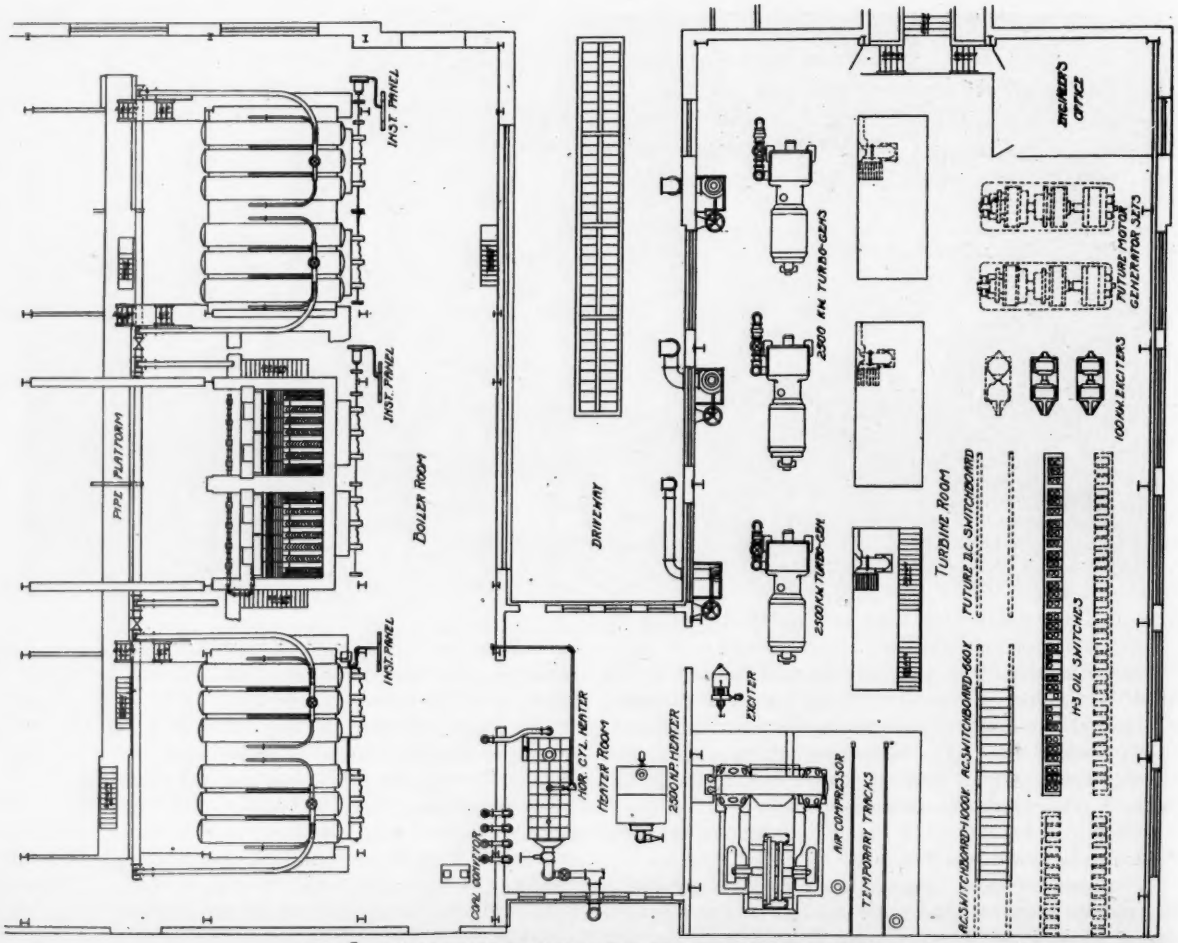


FIG. 2. MAIN FLOOR PLANS OF BOILER AND ENGINE HOUSES

Gravity underfeed stokers serve the boilers, and the furnaces are provided with water backs, or perhaps more definitely called water cooled bridge-walls, designed by the engineering department of the General Electric Co. These consist of vertical water boxes connected top and bottom to headers and cover the entire face of the bridgewall. They not only preserve the bridgewalls from deterioration, but prevent clinker from adhering to them. The cooling water is, of course, used for feeding the boilers so that no heat is lost.

Each boiler setting has an instrument board for controlling the operation of the two boilers. Mounted on the board are steam pressure gages, thermometers, steam flow meters and draft gages. In addition to these instruments, each stoker is equipped with a revolution counter; a feed-water flowmeter is in the line from each of the two feed water pumps; a steam flowmeter is on the steam line to the works and a steam pressure recording gage is on the main steam header.

The boilers are each provided with three blowoff lines; two bottom and one surface; nonreturn valves in the steam leads are provided for protection in case of accident to an individual boiler; mechanical soot blowers aid in keeping the heating surfaces clean.

Feed water is principally heating returns and condensate from the surface condensers; these returns are pumped from a receiving tank to the make-up tank by means of a motor driven centrifugal pump with another pump of same size and type as an auxiliary. The make-up tank also receives the high-pressure drips which are delivered by traps and water bled from the boilers also goes to this tank, thus saving considerable heat.

From the make-up tank the feed water is delivered by a motor driven centrifugal pump, with an extra pump as an auxiliary, to the open feed water heaters, of which there are two. The heaters take exhaust steam from all steam driven auxiliaries and the temperature of the water as it enters and leaves the heaters is registered by recording thermometers. The water pressures in the make-up supply line at the tank and in the feed water line to the boiler are also graphically recorded by gages.

The two boiler feed pumps are of the centrifugal type, turbine driven; one has a capacity of 350 g.p.m. three stages and runs at 2000 r.p.m. driven by a 145-hp. turbine, the other is a four-stage pump with a capacity of 600 g.p.m. and runs at 2350 r.p.m., driven by a 175-hp. turbine.

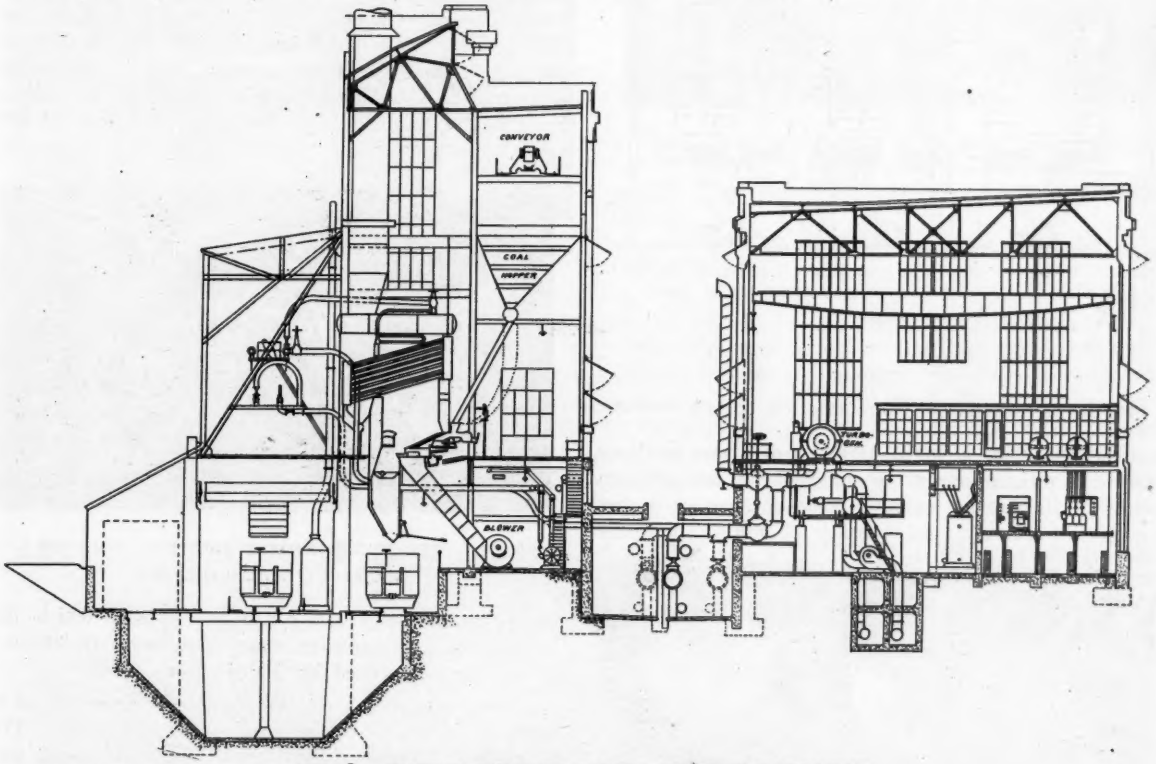


FIG. 3. SECTION THROUGH BOILER AND ENGINE HOUSES

Forced draft is, of course, required for the operation of the furnaces and this is supplied at the present time by three blowers, the plan being to have one blower for the two boilers in each setting. One of these is run at 1475 r.p.m., the other two at 1345 r.p.m., each is driven by an 83-hp. steam turbine. The air pressure carried in the wind boxes is from 4 to 5 in. of water.

Between the boiler room and the turbine room is a tunnel 26 ft. wide by 17 ft. high which carries all steam pipes leading to the factory, the compressed air mains and the condensate piping from the heating system and the manufacturing processes. From the power plant to the central avenue of the works the tunnel takes the form of a twin subway each about 14 ft. square. The high pressure steam transmission pipe is 14 in. in diameter and carries 200 lb. pressure; the exhaust steam used for heating purposes is 36 in. in

diameter and carries 1 to 2 lb. pressure and the pipe for the returns is 12 in. in diameter.

The steam used for heating is extracted from the three 2500-kw. turbines which are so designed as to

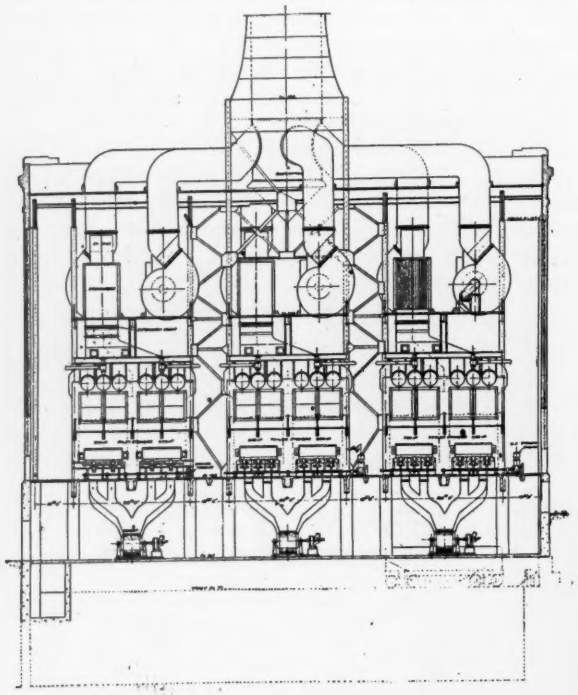


FIG. 4. LONGITUDINAL ELEVATION OF BOILER HOUSE

furnish a total of about 250,000 lb. of steam an hour. This, it is estimated, will be sufficient for the ordinary needs of the works as ultimately contemplated, but during the severely cold weather of winter high-pressure steam is fed into the heating mains through reducing valves at the various buildings.

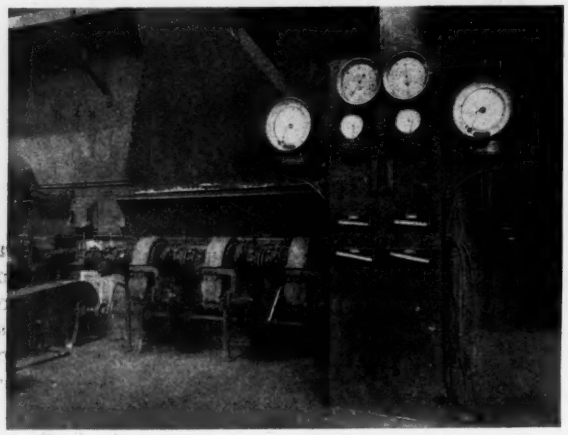


FIG. 5. STOKER FRONT AND BOILER INSTRUMENT BOARD

Electric Generating Equipment

All the generating and power distributing equipment is, as indicated by the illustration, in a separate building connected only through the tunnel. At present, three 2500-kw. turbo generators are installed, these eventually will all be equipped with condensers though at present two are operated non-condensing. They are duplicate units run at 3600 r.p.m. furnishing three-phase current at 600 v. Two of these units are sufficient to carry the load of the plant, so one is used as a spare. During the heating season, steam will be extracted from the second stage, the second stage valve serving to regulate the pressure on the heating system which will vary according to temperature from atmospheric to 5-lb. gage. This extracted steam is conveyed through check valves to the 36-in. header leading to the heating system.

The condenser installed is of the surface type and has a surface of 6000 sq. ft. It is somewhat unusual in that it has tubes $\frac{5}{8}$ in. in diameter and is only 9 ft. long; the diameter of the condenser is thus large in proportion to the length which causes a more direct flow of the steam to the condensing surface than with usual proportions and the results secured seem to justify the design. The circulating and hot well pumps are driven by a 50-hp. motor all on the same shaft run at 870 r.p.m. In place of a positively driven dry vacuum

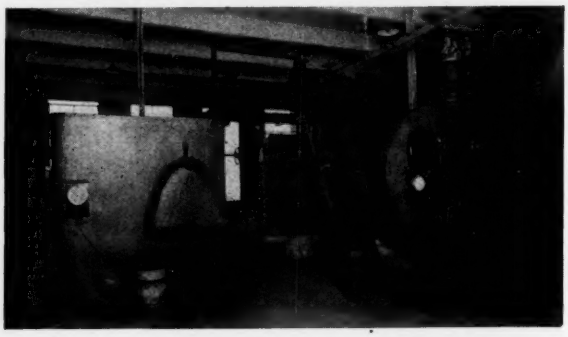


FIG. 6. FEED WATER HEATER SHOWING LOCATION OF RECORDING THERMOMETERS

pump, a two-stage steam ejector is used which discharges into a supplementary condenser which condenses the steam used by the ejectors.

The plant is about a mile from Lake Erie and on an elevation 95 ft. above the level of the lake water. This precluded the use of lake water for condensing purposes, so a spray pond was provided. Near the spray pond is a pump house with space provided for two pumps, only one of which, however, is at present installed. This pump is a double suction single-stage centrifugal, driven by a 65-hp. motor run at 560 r.p.m., and forces the warm circulating water through the sprays. The spray nozzles are arranged five in a group, with six groups to one pipe length extending across the pond and at present there are five of these pipes leading from the main header at the side of the pond. Under average conditions this pond will cool the condensing water 5 deg. or from 80 deg. at which temperature it comes to the pond, to 75 deg., the temperature of the cold water tunnel. It is planned to provide another pond of the same size to care for another 2500-kw. turbine which will constitute the ordinary working equipment under present conditions, no additional cooling equipment is thought necessary at present as this type of equipment is thoroughly reliable, and at

only a slight sacrifice in vacuum the three turbines can be operated from the two ponds with the flexibility of the pumping arrangement; all three turbines can be operated from one pond in an emergency case; or both ponds may be used for one turbine, giving a better vacuum. Parallel tunnels lead to and from the power plant for the cool and warm water, from the cool tunnel the water is drawn by the circulating pumps to the

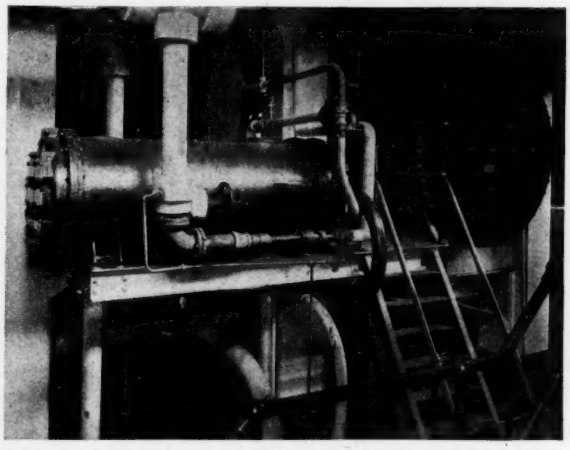


FIG. 8. MAIN CONDENSER WITH AUXILIARY CONDENSER TO THE LEFT

condensers, and from the warm tunnel by the spray pumps. Piping of the ponds is so arranged that in winter the water can be circulated across the pond for surface cooling only, with the sprays cut out; thus a wide variation in cooling may be obtained from surface cooling to full nozzle cooling.

Besides the three main units mentioned above, there are in the turbine room two 100-kw. exciter units consisting of a direct current generator furnishing current at 125 v. direct connected to an induction motor, and one 35-kw. steam turbine driven exciter.

Power Distribution

As previously stated, current is generated at 600 v. but as it was thought likely that at some time in the future a power plant may be built at the lake and power transmitted from there to the works, the transmission voltage chosen is 11,000, so boosting transformers are provided. The main switchboard which is located in the turbine room is designed for remote control, the power for operating the high tension switches being supplied by a storage battery. This battery is also used for lighting in case the regular circuit should fail for any cause whatsoever, and comes into use automatically so that the plant will never be without lights more than during the instant required to operate the automatic switch. The battery is charged by means of a 60 amp.-hr. set.

FIG. 9. VIEW OF SPRAY POND FROM BOILER HOUSE

As will be noted by the accompanying illustrations, the instrument board is directly back of the switchboard, the framework of the two being tied together. The high tension oil switches are placed in a row of separate compartments parallel with the switchboard. The busbars are also in separate compartments built in the masonry work.

Between the power plant and the works, the transmission cables run in underground ducts, and in order to provide flexibility for the distribution of the cables a separate room has been allotted to the cables entering the ducts, this room being located directly under the switching equipment. There is one bank of ducts for 500-v. d.c. cables, two banks for 600-v. a.c. cables, and two banks for 11,000-v. a.c. cables. Each bank of ducts is arranged so that there are only two ducts side by side, and a space for air circulation is provided on either side of the bank. With this arrangement, cable can be taken out from the north or south end of the building and the

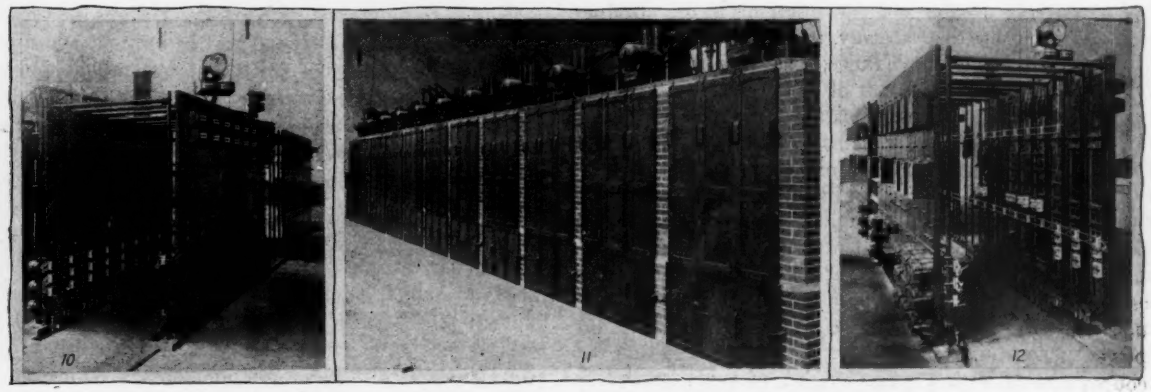


FIG. 10. BACK OF INSTRUMENT BOARD AND FRONT OF SWITCHBOARD LOOKING NORTH IN TURBINE ROOM. FIG. 11. HIGH TENSION OIL SWITCHES IN TURBINE ROOM. FIG. 12. FRONT OF INSTRUMENT BOARD AND BACK OF SWITCHBOARD

ducts can be constructed to meet future requirements as regards the position of the switches.

The transformers are located in a row of compartments located in the basement of the turbine room. Three of the seven installed are single-phase oil and water cooled, 1350-kv.a. rating and boost the voltage from 600 to 11,000; three 940 kv.a. water cooled transformers have the same ratio of transformation, but are connected directly to the condensing turbo-generator while the other three are connected to busbars on both high and low tension sides; the remaining transformer has a rating of 25 kv.a. single phase and steps the voltage down from 600, that at which the current is generated, to 115 and 230 for lighting purposes.

Light and Ventilation

In the design of this plant, particular attention was given to the means for ventilating the various rooms and arranging windows so as to provide as much natural light for the workmen as possible. The coal and ash handling room in the basement of the boiler house is practically one large chamber 74 ft. wide and 28 ft. high, exclusive of the coal pit, which may be kept free from gases by the forced draft fans supplying the furnaces. The basement beneath the firing aisles is provided with outside windows for light and ventilation and the firing aisles are well provided with windows also in addition to the monitor roof which supplies additional ventilation. The economizer room, which is not as yet equipped, and the header aisle are lighted and ventilated by means of the monitor roof. The upper coal storage spaces are isolated from the main boiler room and are provided with outside windows for light and ventilation. The steam subway is provided with monitors and additional ventilation may be had by exhausting the air with the forced draft fans.

The turbine building is equally lighted and ventilated by outside windows, monitors and well openings in the turbine room floor. Air used for cooling the generators is taken from the basement and this aids in keeping the air fresh.

Precautions are also taken to minimize any loss which may be caused by the breaking out of a fire; for fighting fire, two underwriters' fire pumps of 1500 g.p.m. capacity are provided and a sprinkler system is installed. Water for fighting fire may be taken from the city mains, from three storage tanks of 100,000 gal. capacity each or from the spray pond.

As the demand on the plant has grown so that the requirements are more than 5000 kw., it is planned to enlarge the power plant by installing a 6000-kw. generating unit and additional boiler and auxiliary equipment to meet the demands. As the plant grows, strictly condensing units will be installed and the three 2500-kw. units will be used for supplying by-product steam for heating in winter and as spare units to the larger units in summer.

Progress of the World's Power Industry

Progress in the European Power Field. By L. W. Alwyn-Schmidt

THE outstanding feature of all power development abroad during the last 6 mo. has remained the desire for greater centralization of power production. This desire has already taken practical form in England, Germany and France, where in each instance it has led to the development of comprehensive technical projects consisting in most instances in the erection of large central stations of some sort, which in turn are to feed other supplementary stations placed in the distributing field proper. There are in existence in this matter two distinct schools of thought. The one favors the erection of electrical central stations pure and simple, the other proposes the use of gas for operating the central stations for the purpose of winning the by-products from the combustion of coal before it is used for power generation. These two principal projects, of course, appear with a great number of variations. The English scheme most likely will be a combination scheme using both gas and electrical power. Such a scheme is especially suitable for English conditions, owing to the comparative ease by which power and gas can be conducted to large distances from the English coal fields. England has no large waterpowers to speak of with the exception of Scotland and any plan of a central power station, therefore, must be based essentially upon power generation by the use of coal. The English project consequently calls for the erection of such stations somewhere in the Midlands, and a beginning, in fact, has been made already by the erection of a number of giant municipal central stations which will supply with power a very extensive area.

But a complete solution of the various power and heating problems of England will be brought about only by the execution of the full plan, fostered by some of the larger engineering societies and the gas associations. This plan purposes to make use of low temperature carbonization of the coal by a new technical process, the work of carbonization to be done at the pit head. Low temperature carbonization of coal it is claimed has the advantage over the present system of releasing for commercial use certain of the by-products of coal and it is estimated that 1,000,000 tons of coal will give 7,000,000,000 cu. ft. of gas, 3,000,000 gal. of motor spirit, 16,000,000 gal. of fuel oil, 700,000 tons of smokeless fuel, and 9000 tons of sulphate of ammonia. While the by-products will find ready use in the English industry and by their sale will help to reduce the cost of gas making, the gas itself can be used in two different ways. It can either be employed directly for the purpose of heating the boilers of the large central power stations or by driving enormous gas motors to feed the dynamos, or it may also be piped in the ordinary manner to cities in England where it can be distributed to individual consumers. In each case, there is avoided all the trouble of transporting the actual coal. The motor spirit and the fuel oil can further be used for power generation of some sort and the smokeless fuel will be sold to

such domestic fuel consumers that cannot be provided with gas or electric heating.

Here is a perfect scheme of power concentration that has all the advantages of co-operative power production without having the disadvantages of throwing out of work existing power equipment as the gas may be supplied just as well as the coal to the boilers of industrial power stations.

Germany is differently situated in this respect. The country is larger and its coal and power resources are more diversified. In addition, Germany is now cut in two by the so-called Polish corridor to Danzig. Germany has already carried part of its new power scheme in effect during the war by erecting a series of new power stations at various points of Germany which in nearly all instances are owned by the Government. All electrical power rights are now owned by the Government, which holds, in this manner, complete control of all the power sources in the empire. The various large governmental power stations which are hydroelectric plants supported by a number of coal power stations, are linked up by a complicated system of interconnecting stations so that each of the stations supplements the other. In this manner, a permanent supply of power is guaranteed from each station, as the possible lack of water is counterbalanced by the coal power stations. This system of central stations will now be augmented by a new set of stations that are to be erected in the German peat coal regions. Before the war, Germany had given only little attention to the question of peat coal consumption. This coal is not as effective a fuel as ordinary coal, but it has always been used for domestic heating and in some instances also attempts have been made to employ it industrially. To use peat coal as direct fuel, in fact, does not provide any unsurmountable difficulties, as it requires only specially constructed furnaces. The new scheme calls now for a better use of the peat coal by preserving also the by-products of the peat. The by-products of the peat coal are similar to those of hard coal, but the peat is not so rich as its geologically more advanced competitor. Nevertheless, in the present economic state of Germany, the extraction of these by-products will certainly pay and the coal also be used extensively as a fuel after it has been turned into gas. This gas then will be employed for the operation of an additional set of electrical stations which will supply regions of Germany left out of the present system.

A new period of activity therefore has started all over Europe which can be traced clearly all through the most recent power developments in all the European countries.

Large Central Power Station Planned in England

One of the large central generation stations planned in England most likely will be erected near the city of Bradford where the municipality owns a large tract of land bought for the special purpose of erecting one of the central stations supplying the city. The project had not been carried out, owing to the war, and the city is now offering the site to the Government for a similar purpose. In the meantime, the demand for electrical and other power has grown so rapidly that the city cannot wait for the completion of the governmental scheme and has decided to add to its own power facilities by increasing the productive capacity of one of the existing plants. Approximately $1,500,000 will be spent upon the extension. The English problem of power supply cannot be described better than by giving a few figures about the recent extension of the business of one of the power plants supplying such an important industrial center as Sheffield. The municipal power station in Sheffield supplied, during the year 1914, 26,000,000 units of electricity. In the year 1919 the demand had increased to 161,000,000 units and the operating plant has a development of 90,000 hp. The actual requirements of the district are estimated at nearly 600,000,000 units, and a plant, therefore, is contemplated developing 200,000 hp. in all. Sheffield has in addition a gas company that supplies 5,800,000,000 cu. ft. of gas, of which 900,000,000 cu. ft. are required for power. The industry of Sheffield has employed water as its principal power not much more than a century ago. The utilization of small water powers, therefore, is not entirely out of the realm of possibility and the English Government seriously considers putting some of the waterpower sites in England to use for the erection of smaller plants to take care of districts which cannot be supplied centrally by the very large power stations contemplated by the principal development scheme.

Holland Organizes for Power Centralization

The smaller the country the easier is it, of course, to apply centrally controlled power production. It can, therefore, be expected that the plan worked out by a Dutch committee of engineers and experts for providing power for the Holland industries will be one of the easiest to execute and will provide one of the most excellent examples of central production; 125,000,000 florins will be spent for the erection of the buildings, transmission lines, and other equipment. The plan in its present form proposes to make use of the existing private and municipal power plants by linking them up with the new system and providing for a system of high tension transmission lines which will reach practically every corner of the kingdom. The annual consumption of electrical power during the year 1918 was 240,000,000 kw.-hr. only, with a maximum load of 100,000 kw. on the electrical power stations. The estimated requirements of Holland for power and energy are 1,000,000,000 kw.-hr. a year, and a power development of between 3,000,000 to 4,000,000 kw., therefore, will have to be provided. An additional 250,000 kw. are wanted for the purpose of railroad operation. As the whole project will take about 10 yr. to be completed, it is proposed to start by taking over the existing power stations and bringing them up to the highest percentage of efficiency. Construction of the leading distribution lines also will be started immediately. Transformer stations will be placed 20 to 30 mi. apart and 50 transformer stations will be required. For the less densely populated districts, a higher voltage will be used than is required for the more populated parts of the country. Finally the question is considered of having a group of super-stations to produce power in regions where it can be obtained, especially cheaply as is the case in the South Limburg mining district. The execution of the very comprehensive scheme is practically secured and a begin-

ning is to be made very early. Some of the contracts for equipment, in fact, have already been placed.

France to Spend $127,700,000 in New Power Stations

France intends to spend $127,700,000 for hydroelectric power development during the next few years. The French scheme also is fairly comprehensive, but it is limited geographically by the localization of the principal waterpower sites which will make transmission cost rather heavy. Considering that France has available as much as 10,000,000 hp., it is extraordinary that not more attention had been given in the past to hydroelectrical development. The actual waterpower development at the beginning of the war amounted to 80,000 hp. only. During the war, enormous efforts were made to utilize the water powers to relieve the country from the necessity of importing coal in large quantities and 450,000 hp. were developed. Before 1921, the total development will have reached 1,650,000 hp. The investment value of the whole development will be $282,000,000 by the end of 1921, if all plans are actually executed. Of the total available power 4,000,000 hp. are situated in the Alps, 1,500,000 in the Vosges, and the Tura mountains, 1,700,000 in the Pyrenees, while the rest is distributed all over the country. The French scheme is of special importance to Central Western Europe including Germany, as it will relieve the German coal mines of much of the stress put upon them in the past and for the next 10 yr. approximately, by the necessity of having to find fuel for the smelting of the iron in the possession of the two countries. Of course the French coal mines will also help to produce again, but in the past there has always been a race between coal production and coal consumption with the consumption being easily first all along the course. If water power can be utilized at least for most of the French power requirements outside the actual coal region, this will not only remove a very severe strain upon the economic energies of Europe, but it will also do away with one of the latent causes of the past war or any former war in Western Europe, the desire of one country to collect both the coal and iron under its regime. The power engineers in this case will do more for the permanent peace of Europe than has been done by any statesman who has sat at the conference table in Paris.

Austria's Plans for Reducing Coal Consumption

Austria, or that part of Austria which is still left, also is desirous to make the best use possible of its very great water powers to be relieved from the necessity of having to import coal. The electrification of the Austrian railroads is practically agreed upon provided the country can find the 3,700,000,000 crowns that are required for that purpose. By making use of the 2,000,000 hp. of water power existing in Austria, the new republic might easily reduce its coal production at the rate of nearly 50 per cent. The state railroad at present is a very heavy consumer of coal, and it is, therefore, contemplated to let the benefit of the water power development go first to the railroads. Austria has, of course, some coal of her own, but this is generally of low class quality. The surplus of electrical energy will be made available for the use of the national industries.

Sweden Earns 6,000,000 Crowns from Operation of National Hydroelectric Power Plants

That central power development carried on by governments can very well be made lucrative, seems to be shown by the results of the Swedish central power stations. The government reports that its gross income of the operation of the various water sites amounted to 13,897,000 crowns with expenditures of only 7,622,000 crowns which is not so bad at all, considering the present high expenses of all industrial operation. Following the lead of other European countries Sweden is now engaged in converting her railroads from steam operation to electrical operation. Parliament has approved an expenditure of $6,000,000 for the electrification of the governmental railroad system between Stockholm and Goeteborg. The scheme will require about 5 years for completion.

Southeastern Europe Offers Great Possibilities for Power Enterprise

In view of the great interest taken by the American nation in the industrial development and the pacification of Southeastern Europe and Asia Minor, any industrial news coming from this region always compels special attention. Under Turkish regime, these regions have never been able of free development and industrial enterprise has greatly suffered from national mismanagement. When the Turks finally lost their hold upon the largest part of the Balkan Peninsula after the first and second Balkan war, the nations taking their place were so much occupied with their own troubles that they found no time to apply themselves to development work and the great opportunities that offered themselves to the power engineer in the Balkans were left unused. The European war finally put an end to all thought on further industrial work, and only now attempts are made to organize economic life in the Balkans upon a modern basis. Greece has taken in hand the provisioning of her industries with electrical power and use will be made of the comparatively large hydroelectric forces obtainable in Macedonia. All in all about 70,000 hp. may be obtained there from sites of various strength and importance. Most of the water power now employed in that part of the Balkans is drawn directly from water wheels. It is now contemplated to arrange for modern turbines and convert the energy into electrical power which can be then transmitted over a wider territory. The development of the Macedonian water powers is very much favored by the fact that all the best power sites are located along the railroad. It will, therefore, be easy to transport the material and equipment and the new industries that may spring up, attracted by the power will find a convenient form of distributing their products. A study is now made with a view of obtaining data for the construction of power plants and especial attention is given to the possibility of uniting smaller water systems for the purpose of using their power jointly for the operation of high power plants. It is likely that the capital for this development will come from Swiss sources as Swiss engineers have been employed for making the necessary surveys.

Also the Transcaucasian situation may soon call for

some attention in this country. It is said in a recent consular report that Transcaucasia will witness a great development in the utilization of its potential water powers for electrical power generation. Surveys have established the possibility of developing 350,000 hp. in that region and the present day development amounts to 6725 hp. only. The main difficulty still standing in the way of developing these powers is of a political nature. Intermittent fighting is still going on in the republics of Georgia, Azerbaijan and Russian Armenia, and no useful work can be done under such circumstances. But the district is rich in mining and agricultural possibilities and the few power stations that have been in operation or are still doing work have been all comparatively prosperous.

We have not learned yet as a nation to employ our large facilities outside our boundaries in the manner done by the English and German engineers. But it is absolutely necessary that we should make a start, especially as we can give to the world the experience gained under the most difficult conditions. American power engineers who would make a study of conditions in Transcaucasia, most likely, would find this a very paying enterprise especially as the district seems to be very suitable for the operation of small power plants owned by private capital or small companies. The country which helps to solve the power problem of that region will not only receive the orders for the equipment, required for the central stations, but will lead also in the supply of industrial and agricultural machinery for which there is an enormous demand. There are at present in operation 20 stations, 8 stations have been authorized with a total development of 158,000 hp. and other projects amounting to 213,000 hp. have been proposed. Besides that, no doubt many other good opportunities would be found.

Improving the Circulation of Steam Heating Plants---II

DESCRIBING THE PROPER METHOD OF AIR VENTING FOR VARIOUS CONDITIONS. BY CHARLES L. HUBBARD

POOR circulation in connection with a steam or hot-water heating system, which is indicated by cold sections in coils and radiators, is nearly always caused by imperfect air venting.

Steam and air cannot occupy the same space at the same time, hence the air which is always present when steam is turned into a cold coil or radiator must first

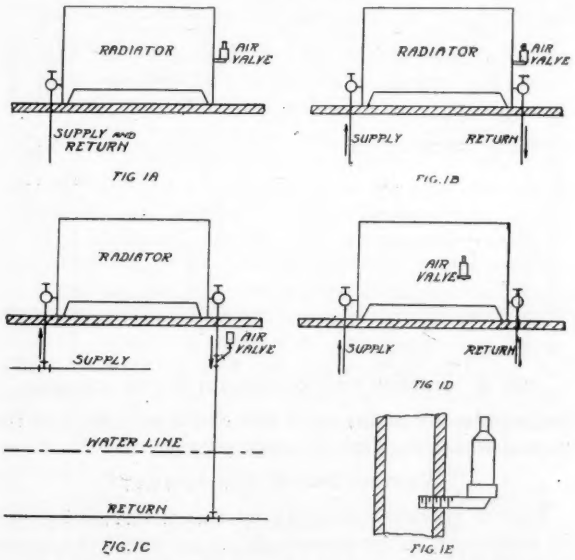


FIG. 1. METHODS OF FITTING AIR VALVES TO RADIATORS UNDER VARIOUS CONDITIONS

be driven out before steam can fill the entire interior and so give full value to the heating surface. Air venting for both steam and water is a simple matter; but if the connections are not properly made, pockets will be formed which hold the air and seriously interfere with the circulation of both steam and water. Air is heavier than steam and lighter than water so that the method of removal from the two systems is materially different.

AIR-VENTING FOR STEAM SYSTEMS

IN CASE of the ordinary sectional cast-iron radiator, the air valve is placed at the return end about half the way up from the floor, as shown in Figs. 1A and 1B.

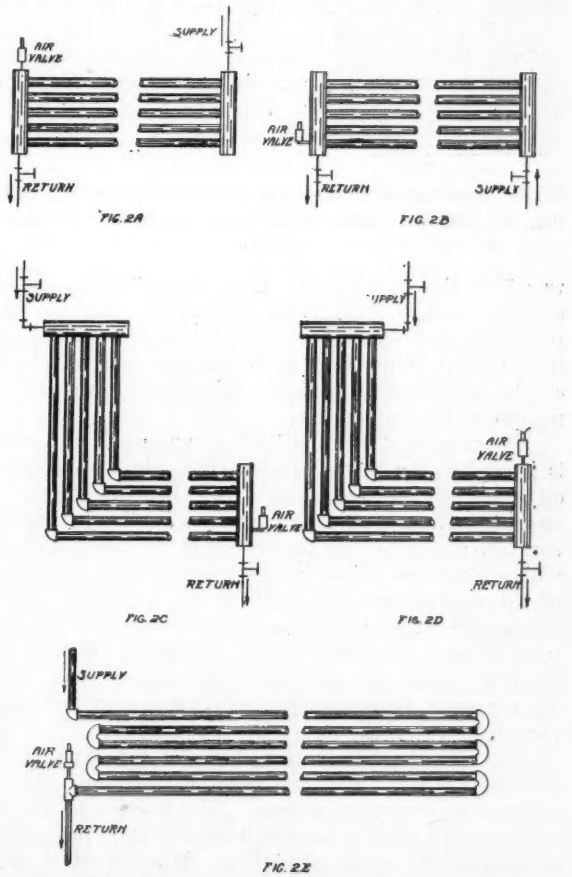


FIG. 2. SHOWING PROPER LOCATION OF AIR VALVES ON DIFFERENT TYPES OF CIRCULATING COILS

Steam entering at the left gradually fills the sections, thus forcing the air toward the other end where it is discharged automatically through the valve or vent. If, in any case, it is desired to keep the air valves in the basement, where they are easily inspected by the engineer, and where the vent piping will not show, separate returns may be carried down from each radiator or coil and the air valve connected with the side, well above the water line, as shown in Fig. 1C.

This applies especially to one-story buildings like stores, churches, halls, banking rooms, etc., as in higher buildings separate returns to the basement from each radiator would complicate the piping too much.

When hot-water radiators are used for steam work, as is sometimes done, the air valve should be placed as indicated in Fig. 1D; that is, about two-thirds the

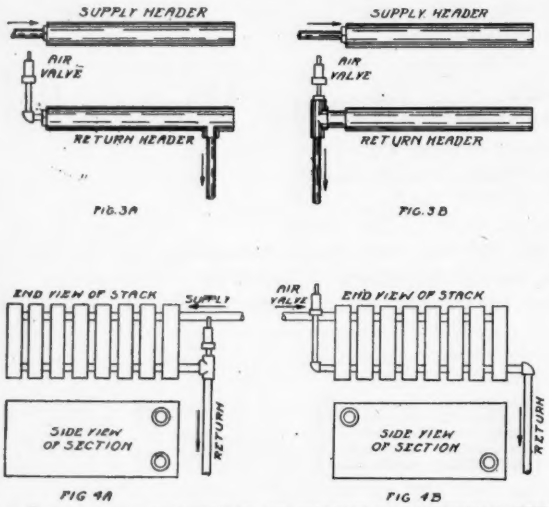


FIG. 3. METHOD OF FITTING AIR VALVES TO OVERHEAD COILS
FIG. 4. PROPER LOCATION OF AIR VALVES ON INDIRECT STACKS

way from the supply valve. The reason for this is that a steam passage through the radiator at both top and bottom tends to pocket the air at the point shown by the air valve rather than at the extreme end, as in case of the usual steam radiator which has a continuous passage at the bottom only.

Dripping or "spitting" of an automatic air valve is generally due to the condensation which runs down on the inside surface being drawn into the discharge opening of the valve by the stream of air passing through it. This can be prevented by using a valve with a long stem which projects beyond the inner wall of the section (see Fig. 1E) or one provided with a special attachment which causes the water to drain back into the radiator rather than to be forced out with the air and steam. In the case of circulation coils, there are a greater variety of connection and therefore more chance for air pocketing.

Two of the most common forms of this type of coil are the "mitre," and the plain branch coil carried around the corner of a room. The position of the air valve in both of these cases will depend upon the method of making the steam connection. When steam is supplied at the top of the heater, as in Fig. 2A, the air valve should be placed in or near the top of the return header, because steam entering at a considerable velocity first passes to the bottom of the header, and then through the lower pipes, forcing the air upward in the return header. If the air valve were placed near the bottom, opposite the lower pipes, steam would strike and close it before the air had been driven from the upper pipes.

The reverse condition is shown in Fig. 2B. Here steam enters the bottom of the supply header, passes through the upper pipes first and forces the air to the bottom of the return header. Steam cannot come in contact with the valve until all of the pipes of the coil have become filled and the air completely removed.

The same principle applies to mitre coils and the correct location of air valve for different conditions is shown in Figs. 2C and 2D. In the "trombone" or return-bend coil, the air is driven in front of the steam to the return outlet and the important point is to locate the air valve so that the condensation will not choke it and cause it to drip while discharging air. A good arrangement for this form of coil is shown in Fig. 2E.

Overhead coils require special treatment to prevent dripping. Two good arrangements are shown in Figs. 3A and 3B which illustrate corresponding supply and return headers with the proper position of air valves to prevent pocketing and dripping.

Two methods of air venting indirect stacks, made up of pin radiator sections, are illustrated in Figs. 4A and 4B. The first of these shows a case where the connecting nipples are at the same end of the sections, and the second where they are at opposite ends.

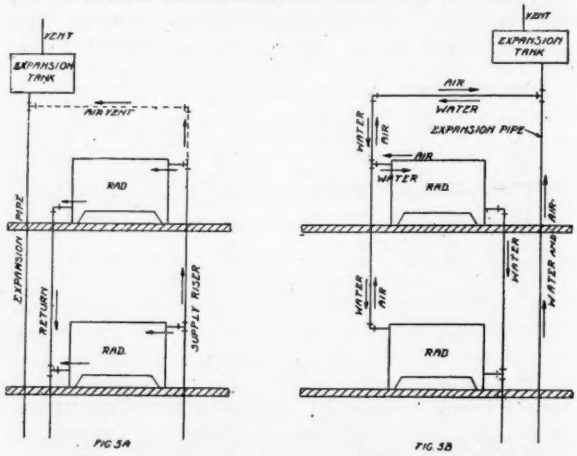


FIG. 5. METHOD OF VENTING HOT WATER SYSTEMS

Venting Hot-Water Systems

Only systems operating by forced circulation will be considered in the present article, as these are the ones with which the operating engineer has most to do. As already stated, air is lighter than water, and therefore tends to rise to the highest point in the system. In the installation of new work, it is best to design the pipe connections so the air may work upward to the expansion tank, if possible, without the use of air valves on the radiators. This may be done by making the supply connection with the top of the radiator or coil in all cases and venting the top of each supply riser, as shown in diagram in Fig. 5A. If an overhead system of distribution is used, with a downward supply, the move-

ment of water and air will be as indicated by the arrow in Fig. 5B. When the system is operated with an "open" expansion tank, the air simply passes out through the vent; but if the "closed" system is employed, the air must be discharged from the extreme top of the piping or tank by means of an air trap. If the supply connections with the radiators are at the bottom, then a pocket will be formed and an air valve or vent pipe must be connected with the top of each unit.

In general, whenever a coil or radiator fails to become steam hot in all parts, first adjust the air valve so as to discharge properly; then, if conditions are not sufficiently improved, study the location of the valve in connection with the accompanying diagrams. If there is trouble from dripping or "spitting," use a valve which projects through the wall of the radiator, as in Fig. 5, or one having a special drainage attachment. If used on a coil, provide good drainage around the air valve connection by using a large fitting as in Figs. 10, 12 and 13. If dripping occurs in Figs. 6 to 9, extend the valve stem inside the header so as to carry the air inlet away from the wall of the header. When air binding is more or less general, the use of an air-line vacuum system provides a simple way of overcoming the difficulty, as all air is quickly drawn from the system by this method, together with any water which may drip through the valves.

Stopping Fuel Waste in a Modern Boiler Room

By W. M. McNeill

THE MANAGER of a large steam electric power plant has been having his trials, troubles and tribulations. His plant was modern in every sense of the word. He had the best in the way of boilers and stokers, the plant was equipped with a full line of efficiency instruments and his operators were all high class men, but they did not seem able to get the results to be expected in a plant of this size. The manager had changed chief engineers; he had employed efficiency and production engineers, but the results were no more satisfactory than before. The coal consumption per kilowatt-hour remained constant at about 4 lb., the evaporation factor refused to come up and the cost per kilowatt-hour refused to come down. The prime movers were all of modern design and had proved by test to be economical in the use of steam, thus the blame for the losses was fastened on the boiler room equipment.

The boiler room equipment consisted of six 500-hp. and six 1000-hp. boilers, all served by chain grate stokers of the best design. Each boiler had its own mechanical soot blower as well as draft control, draft gages and CO_2 recorders. The feed water was controlled by regulators which maintained a regular water level under all conditions. The boilers were found to be clean externally and internally. The CO_2 was found to range from 9 to 12 per cent which was considered good. No leaks were to be found in any of the steam or hot water lines. The auxiliary equipment was all in first class condition, and from all appearances the plant would have been expected to be efficient; the losses were going on just the same.

The services of a combustion engineer were secured and he immediately started in search of the loss, which looked as if it would be some job to locate. However, he did not look long, until he discovered at least one of the causes of the manager's worries. On looking over the cinder pile, he noticed large quantities of coke and coal which were only half burned. The plant had changed coal about 6 mo. prior to this time and the firemen had not learned how to burn the new coal and the chief engineer was too busy to go down into the boiler room and coach them in the use of this new coal. Balanced draft was installed in connection with these stokers; the firemen were carrying the fuel bed too thick and were driving the grate too fast, thus not allowing the coal sufficient time to be completely consumed before reaching the water back and being dumped into the ash pit. The CO_2 was high because the right amount of air was supplied by the fan, the settings were tight and a high furnace temperature was maintained. The fuel bed was thinned down to about 5 in., the water back lowered and the trouble was at once eliminated.

The next source of waste was not so easily located. Feed water was heated by two large open heaters. The condensate from the turbines was returned to the heater to which the make-up water was added. Steam was supplied for the heaters by the vacuum pumps, fan engines and feed pumps. A thermometer was placed in the feed line and the feed water was found to be about 150 deg. F. The auxiliary equipment was all arranged so that it could be run condensing or allowed to exhaust into the feed water heaters, thus just the right amount of exhaust steam could be supplied to the feed water. Two more vacuum pumps were allowed to exhaust into the heater and the water was raised to 210 deg. F.; the effect was noticed on the coal pile at once.

The combustion engineer noticed that the siftings from the chain grates were being wheeled out and thrown into the cinder pile. He asked the head fireman why the siftings were not burned and was told by this individual that the siftings were not worth burning; however, the combustion engineer was of the opinion that several million heat units were being allowed to escape in this manner and at once set about instructing the firemen in the proper way to burn them. The firemen in the past had tried to burn these siftings without mixing with fresh coal. A large amount of siftings were allowed to collect under the stoker and all were raked out and put in the hopper at once, of course, the fire would almost go out and the steam would go down. By mixing with fresh coal, these siftings were easily burned and thus a considerable saving was effected.

In unloading coal by a drag-chain conveyor and dumping into an open storage pile, the high winds carried away a considerable amount of coal dust which was, of course, perfectly good fuel. In order to overcome this, a long flexible chute was made of heavy duck, one end being fastened to the discharge of the conveyor, the other end reaching almost to the coal pile where it was desired to deliver the coal.

After these and a few other "common sense" remedies were applied, a test was run and it was found that the coal consumption per kilowatt-hour had dropped from 4 lb. to 3¼ lb. and the combustion engineer called it a day and went home.

Estimating Relative Values of Coal, Oil and Gas as Fuels*

Charts for Convenience in Making Calculations. By L. C. Lichty

THE FIRST question asked by a plant engineer when discussing the proposition of changing from coal to oil or vice versa, is whether it pays to make the change. There are six items usually considered before making a change:

1. Cost of coal and oil at the plant.
2. Calorific values of each fuel.
3. Overall boiler efficiencies in each case.
4. Effect on capacity of boilers.
5. Expense of making change.
6. Effect of change on life of boilers.

It is practically impossible to design a comparative chart which would include all six items, on account of the last three which depend almost entirely upon plant design; however, the first three are items that can be handled in a chart and are items in which the plant

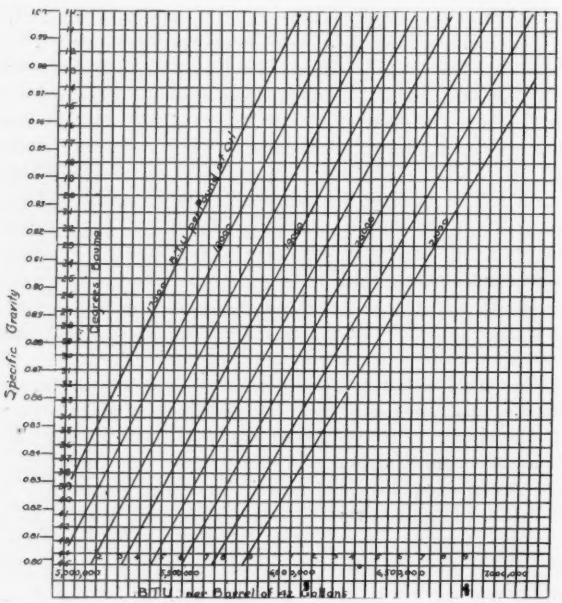


FIG. 1. CHART FOR DETERMINING THE B. T. U. PER BARREL OF OIL

engineer is or should be well versed. The cost of the fuels and their respective calorific values are usually known. In a modern plant, the overall boiler efficiency with the fuel used is known. So the only problem in hand is to know what the efficiency will be when burning the fuel to which it is proposed to change, whether coal or oil.

The Coal vs. Oil Chart, which was published in the July issue and which is incorporated in Fig. 3 with the addition of gas curves, is so arranged that a direct comparison between the cost per ton of coal and cost per barrel of oil can be made, no matter what the grade or calorific value of fuel may be. Since coal is purchased by the ton and oil by the barrel, it is necessary to know the heat value per pound of coal (since a pound is a definite proportion of a ton) and the B.t.u. per barrel of oil in order to make a comparison of costs on a B.t.u. basis.

The coal curves are plotted against cost per ton as the ordinate and B.t.u. per cent as the abscissae, the coal curves representing certain calorific values.

The oil curves are plotted against cost per barrel as the ordinate and B.t.u. per cent as the abscissae, the oil curves representing the different calorific values of various oils per barrel.

The efficiency curves are drawn so that if a line is dropped from any value along the abscissae to any efficiency line and then horizontally to the vertical axis the point of intersection with the vertical axis will lie below the intersection of the axes a distance equal to the efficiency made use of times the distance from the intersection of axes to point where the vertical line was dropped to the efficiency line.

To make a comparison first make use of the heat content per barrel chart, Fig. 1, from which the B.t.u. per barrel of oil of certain grade and calorific value is determined. Then starting at the cost per ton of coal proceed to the right until reaching the B.t.u. per pound of coal curve; from this point, drop down until intersection is made with the efficiency line representing the efficiency burning coal. Here turn to the left and follow a horizontal line until intersection is made with the efficiency line representing the efficiency burning oil. From this point, follow a vertical line until the B.t.u. per barrel of oil curve (previously determined) is reached. Here turn to the right and follow a horizontal line until the scale of oil prices is reached. The price indicated is that which will give the same cost performance as the coal in the comparison.

It will be noted that the efficiencies are the variable which are somewhat problematical, and upon which the correctness of the comparison will lie. There is considerable difference of opinion regarding the boiler efficiency when using coal or oil as the following statements will show:

F. W. Staley, Engineer, The Texas Co., states:

"In enumerating the advantages of oil fuel over coal, higher efficiencies are obtained with the former. With boilers of approximately 500 hp. equipped with properly designed furnaces and burners, an efficiency of 83 per cent is possible or, making an allowance of 2 per cent for steam used by burners, a net efficiency of 81 per cent. The conditions under which such efficiencies are obtained are distinctly test conditions in which careful operation is a prime requisite. With furnace conditions that are not conducive to the best combustion, this figure may be decreased by from 5 to 10 per cent. In large properly designed plants, however, the first named efficiency may be approached for uniform running conditions, the nearness to which it is reaching depending on the intelligence of the operating crew. It must be remembered that the use of oil fuel presents to the careless operators possibilities for wastefulness much greater than in plants where coal is fired; therefore it pays to go carefully into the feature."

* Paper presented before the Southwest section of the A. S. M. E.

T. P. Leask, Gilbert and Barker Mfg. Co., states:

"That efficiencies of 71 and 75 per cent on boilers operating on fuel oil are easily obtainable as has been demonstrated on repeated tests."

D. M. Myers, Consulting Engineer, N. Y. City, states:

"Under equally favorable conditions, it is true that a somewhat higher efficiency can be obtained with oil than with stoker fired soft coal. On the other hand, an oil fire may be flooded with a tremendous excess of air without indicating the fact to the operator, as a coal fire would under the same conditions. It is really easier to fail in the efficient operation of oil than with coal

	Boiler and Furnace Efficiency, Per Cent.
Bituminous coal, hand fired	63
Bituminous coal, modern stoker	73
Small anthracite, hand fired	60
Fuel oil, oil burners	73
Natural gas, gas burners	73

It will be noted that the efficiency of a modern stoker fired coal plant is assumed the same as when oil fired, a difference of 10 per cent in favor of oil when the coal is hand fired.

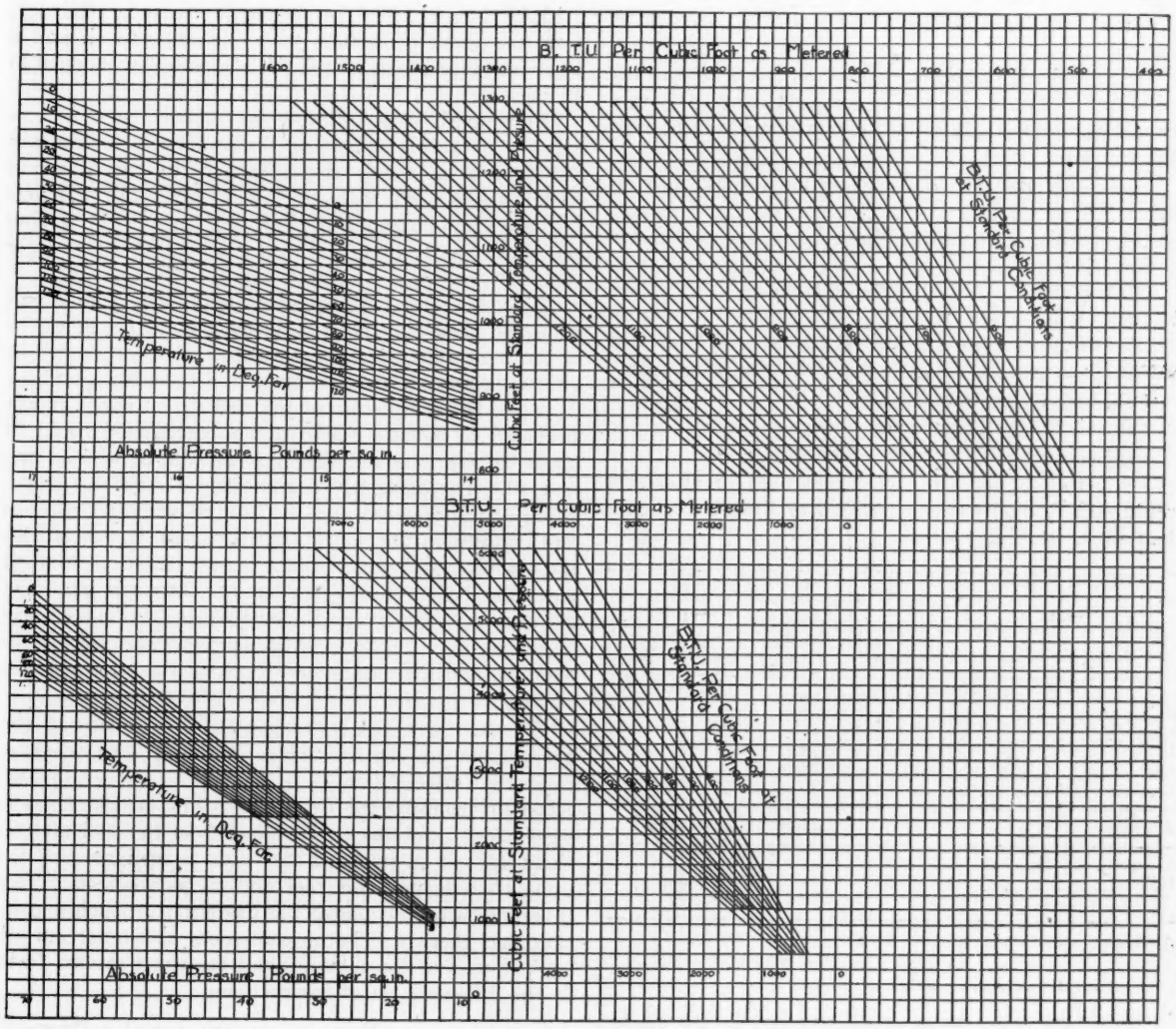

B. T.U. Per Cubic Foot as Metered
Temperature in Deg. Fahr.
Absolute Pressure Pounds per sq. in.
Cubic Feet of Standard Gas at Constant Temperature and Pressure
B.T.U. Per Cubic Foot at Standard Conditions
B.T.U. Per Cubic Foot as Metered
Temperature in Deg. Fahr.
Absolute Pressure Pounds per sq. in.
Cubic Feet of Standard Gas at Constant Temperature and Pressure
B.T.U. Per Cubic Foot at Standard Conditions

FIG. 2. GAS CONVERSION CHART

so that in the long run, especially in small plants, it is quite possible that an efficiency with oil might run below that which would probably obtain with coal. In a recent examination of a plant, there was found an extravagant waste of oil on account of the reasons first stated. It is perhaps fair to state that the same thermal efficiency is obtainable with either oil burners or stokers." In a table in which he shows the cost of evaporations with various fuels, he uses the following efficiencies:

G. B. Nichols, in a discussion of a paper on oil as a fuel, states: "From 5 to 10 per cent higher efficiency can usually be obtained from oil over coal. I doubt very much if efficiency over 82 per cent can be maintained. Some engineers operating plants equipped with oil burning equipment even go so far as to say that they have not been able to make any gain in efficiency."

F. H. Daniels states: "Of course, under the best of test conditions, fuel oil has shown over-all boiler effi-

ciencies up to 82 per cent, and some tests show even above this. But the up-to-date mechanical stoker can show equally good results and it is fair to assume that under average operating conditions the efficiency of furnaces using fuel oil will be no greater than that obtained with mechanical stoker burning coal of 12,500 B.t.u. and higher. This average of efficiency would range from 65 to 75 per cent, depending on the average size of the plant, kind of coal or fuel oil used, the average rating at which the boilers are operated and the fluctuations in load." Later on, "In connection with this question of efficiency, almost all load installations burning oil use high pressure steam atomizers. The steam required amounts to about 2 per cent of the boiler output under ideal conditions and it may go as high as 5 per cent.

H. A. Wilcox, in an article entitled "A Fuel-Oil Installation" which appeared in a recent issue of Power Plant Engineering, gives the following test results with coal and oil:

Coal test, 8.78 lb. Water from and at 212 per lb. fuel.

Oil test No. 1, 14.06 lb. Water from and at 212 per lb. fuel.

Oil test No. 2, 13.92 lb. Water from and at 212 per lb. fuel.

Assuming as before 13,000 B.t.u. per lb. coal and 19,000 B.t.u. per lb. oil gives the following efficiencies:

Coal test, 66 per cent efficiency.

Oil test No. 1, 72 per cent efficiency.

Oil test No. 2, 71 per cent efficiency.

Deducting 3 per cent for steam used in atomizers would make the oil test efficiencies 2 to 3 per cent higher than when burning coal.

Authority	Coal		Fuel Oil	Natural Gas
	Hand Fired	Stoker Fired		
Staley			81	
Leask			73	
Myers		73	73	73
Nichols		72.5	80	
Daniels		70	70	
Average		71.8	75.4	
Myers	63		69	
Wilcox	66		68	
Average	64.5		68.5	

"The coal tests were made just before the boilers were cut over and the oil tests were made after the oil plant had been in operation for some time in order to get the fireman accustomed to regulating his fires." It is stated that no attempt was made to get a special record with either coal or oil and that they were simply interested in determining the relative value of coal and oil as fuel in developing steam under their conditions.

Suggested values for stoker fired boilers when burning coal, 72 per cent; when burning fuel oil, 76; for hand fired boilers when burning coal, 65; when burning oil, 69.

These values of efficiency were tabulated under the heads of Hand Firing, Stoker Firing and Oil Fuel. Averages were determined for Hand Firing and for Oil Fuel under the boilers which were originally hand fired, also for Stoker Firing and for Oil Fuel under the boilers which were originally stoker fired, with the following results:

Hand fired .....64.5 % Oil fuel.....68.5 %
Stoker fired .....71.8 % Oil fuel.....75.4 %

It is suggested that, for use with the coal and oil chart, efficiency of 65 and 69 be used for the first case and 72 and 76 for the second case. In other words, in case the plant operator knows the efficiency, say, of burning coal in his particular plant, which is stoker fired, he should expect a 4 per cent increase in efficiency, from the above deduction, when changing to oil and a 4 per cent increase in a hand fired installation changed to oil burning.

In general, it is believed that using the same efficiencies in a comparison of the two fuels, unless one shows up at a considerable advantage in cost, it would be unwise to make a change. That is, if the coal performance would equal the oil performance by giving the oil a slightly higher efficiency than that allowed for coal, it would be unwise to change to oil.

Also, since the plant operator is the man who is best informed regarding the conditions around his plant, he is the man who should say what efficiencies should be used in making a comparison of the fuels for his plant.

Since the completion of the coal vs. oil chart, it was proposed to include gas so that a comparison could be made between gas and coal, gas and oil, as well as coal and oil. The handling of gas offers a different proposition. It is metered and paid for at various pressures and in addition the calorific value per cu. ft. varies with the absolute pressure, absolute temperature and kind of gas. The curves needed for gas are B.t.u. per cu. ft. of gas as metered. Getting their values and taking a range of prices, the B.t.u. contents per cent can readily be obtained and the curves plotted using the same abscissa as used on the coal vs. oil chart. (B.t.u. per cent.)

To determine the B.t.u. per cu. ft. as metered, the gas conversion chart is made use of. Two pressure ranges are used, 14 to 17 lb. abs. and 17 to 60 lb. abs. After determining the B.t.u. per cu. ft., scales of prices were chosen and the curves plotted on the coal and oil chart against an inverted cost scale as ordinate and the same scale as used for coal and oil as abscissae. This inverted cost scale places the gas curve in such a position that there will be no confusion with other curves.

The uses of the coal, oil, and gas chart are set forth in the following set of instructions.

Instructions for Use of Coal, Oil and Gas Performance Chart

In general, before making use of the coal—Oil and Gas Performance chart, it will be necessary to refer to one or perhaps both of the smaller charts, depending upon which two fuels are to be compared. If a comparison is to be made between the three fuels, all three charts will be made use of.

1. Use of the B.t.u. pr BBl. of Oil Chart

When oil is one of the fuels to be compared the B.t.u. per barrel chart is first made use of. Knowing

the specific gravity or degrees Baumé, follow a line from this point to the right until the B.t.u. per pound of oil line is reached. Then follow a vertical line down to the base of the curve sheet where the B.t.u. per barrel can be determined.

2. Use of the Gas Conversion Chart.

When gas is one of the fuels to be compared, reference will first be made to the gas conversion chart. If the pressures are low (ranging from 14 to 17 lb. per sq. in. abs.), the upper half of the chart will be made use of. While if the pressures range from 17 to 70 lb. per sq. in. abs., the lower half of the chart will be made use of. In either case the determination is identical. From the absolute pressure in pounds per square inch, at which the gas is metered, follow up a vertical line until an intersection is made with the temperature line at which the gas is metered. From this intersection turn to the right, follow a horizontal line (crossing a scale which gives the cubic feet of gas at standard pressure and temperature equivalent to 1000 cu. ft. at the meter under the actual conditions) until intersecting the line representing the B.t.u. per cubic foot of gas under standard conditions. From this point, follow up a vertical line until the scale giving the heat contents per cu. ft. as metered is reached.

3. Coal and Oil

Now if a comparison between coal and oil is to be made, start with the price of coal per ton and follow a horizontal line to the right (on the large chart) until reaching the B.t.u. per pound of coal curve. From this point, drop down on a vertical line until intersecting a line representing the over-all boiler efficiency when burning coal. From this point, follow a horizontal line to the left until intersecting the line representing the over-all boiler efficiency when burning oil. From this point follow up a vertical line until intersection is made with the B.t.u. per barrel of oil curve, which value was determined in paragraph 1 of these instructions. From this point follow a horizontal to the right until the scale of price of oil per barrel is reached. The price indicated will be that which would give the same operating cost when burning coal.

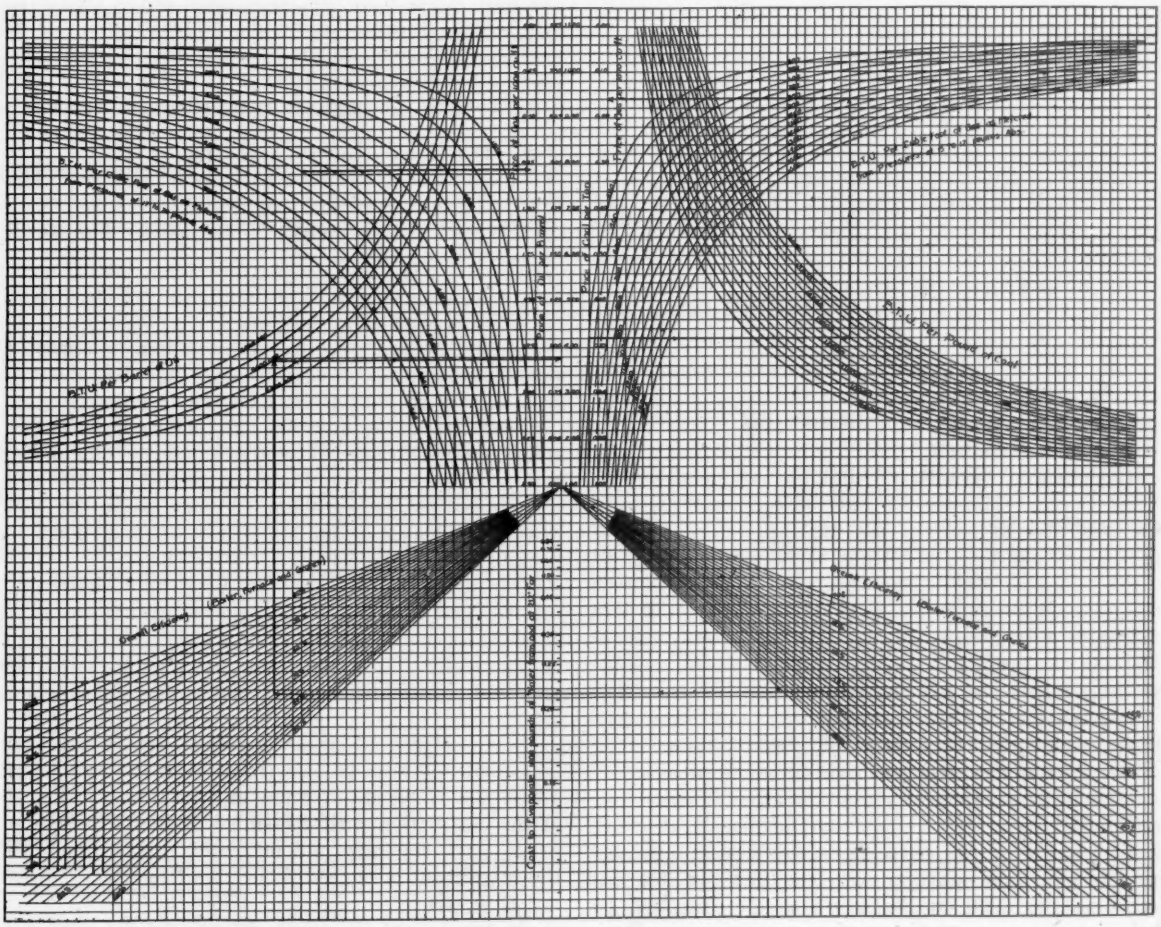


FIG. 3. CHART FOR COMPARISON OF COAL, OIL AND GAS AS FUEL

4. Coal and Gas

It will be noticed on the large chart, as in the Gas Conversion chart, that the gas curves are divided into two separate pressure ranges. Hence in a comparison between coal and gas the lines and directions to be followed will depend upon whether the gas is in the lower or the higher pressure range. If in the lower range, starting with the price of coal per ton, follow the

directions given in paragraph 3 until the efficiency line when burning coal is reached. Then follow a horizontal line from this point either to the right or left (depending whether the efficiency burning gas is less or greater then that when burning coal, respectively), until the efficiency burning gas is reached (which in this case will lie in the same set of curves as the efficiency when burning coal). Then from this point follow up a vertical line until the B.t.u. per cubic foot of gas as metered curve is reached. (Note: This value is determined as explained in paragraph 2.) From this point, follow a horizontal line to the left until the scale of prices of gas per 1000 cu. ft. as metered is reached. This will indicate the cost of gas per 1000 cu. ft. which will give the same performance as that obtained with the coal.

To make a comparison between coal and gas, when the gas pressure ranges from 17 to 70 lb. abs., start with the price of coal per ton and follow instructions given in paragraph 3, but instead of stopping at the B.t.u. per barrel of oil curve, continue upward until intersecting the B.t.u. per cubic foot of gas as metered curve. From this point, follow a horizontal line to the right until the scale of prices of gas per 1000 cu. ft. as metered is reached. This will give the cost per 1000 cu. ft. of gas as metered, which will give the same performance as the coal referred to. It will be noted that there are two scales of prices of gas per 1000 cu. ft. the one on the right-hand of the vertical center line referring to the low pressure gas, while that on the left-hand side refers to the high pressure gas.

5 Oil and Gas

Comparisons between oil and gas are made in an exactly similar manner to those of coal and gas with the exception, of course, that the B.t.u. per barrel of oil line and the price of oil per barrel are used instead of the values for coal. Comparison can be made between oil and high pressure gas in a similar manner to that of making a comparison of coal and low pressure gas as explained in the first half of paragraph 4. A comparison between oil and low pressure gas can be made in a manner similar to that in comparing coal to high pressure gas as explained in the last half of paragraph 4.

6. Cost of Evaporation

A scale of costs to evaporate 1000 lb. of water from and at 212 deg. F. will be found on the large chart. With any one of the three fuels this cost can readily be determined by starting with the cost per ton, per barrel or per 1000 cu. ft. of gas as the case may be, following a horizontal line until intersecting the B.t.u. curve, then dropping a line from the B.t.u. curve on the fuel in question to the over-all boiler efficiency line when burning that fuel, then follow a horizontal line until intersection is made with the cost scale above referred to.

7. Special Features of the Gas Conversion Chart

The gas conversion chart can readily be used to determine the number of cubic feet of gas under standard conditions equivalent to 1000 cu. ft. of gas under the pressure and temperature as metered. Instructions for determining this are given in paragraph 2.

If a calorific test of a gas is made under conditions which are not standard, it is usually desirable to convert this to B.t.u. per cubic foot under standard conditions. To do this follow up a vertical line from the absolute pressure at which the gas was tested until intersecting the temperature line, which represents the temperature of the gas also when tested. From this point follow a horizontal line to the right until intersection is made with a vertical line drawn down from the value representing the B.t.u. per cubic foot of gas as determined in the calorific test. The intersection of these two lines will lie on a curve which represents the B.t.u. per cubic foot of gas under standard conditions.

In natural gas work standard conditions are arbitrarily taken as 14.65 lb. per sq. in. absolute and 60 deg. F., upon which conditions the gas curves in these charts are based.

Credit is due Floyd E. Warterfield, senior mechanical engineering student, University of Oklahoma, for the excellent work done in the construction of these charts under direction of the author, and for valuable suggestions made by him and incorporated in the charts.

Hydroelectric Power Developments

PRACTICAL POINTERS ON DEVELOPING SMALL WATER POWER SITES. BY TOM THUMB

AT DIFFERENT times, the power plant worker has new ideas sprung upon him, yet they are old ideas slightly remodeled.

At the present time we are reading in almost all magazines, whether mechanical or otherwise, about the great saving to be derived from water power.

There can be no question but that water power is a great power—steady when controlled by our modern hydraulic governors and almost perfectly reliable. I say almost perfectly reliable because there are times when back water or an ice jam will break down our power for a short period.

One point which I wish to dwell upon, however, is the fact that owners are being encouraged to install isolated water power plants that are designed to operate automatically. In order that water power shall pay proper dividends labor in the small plant must be done away with.

Water is not all profit. A small hydro plant may be installed a mile or two from the main unit to take advantage of a body of water or a good head. The cost of the installation with transmission lines will be a surprise to the ordinary mill or factory owner; and when the investment is figured, it is found that this power is not all gratis.

In the case of the textile manufacturer, many times he enlarges a hydro plant and perhaps stops a steam unit and then finds that his fuel consumption has not dropped materially. The answer is quite easy. He is now using live steam in his process that formerly went through the engine first.

In certain localities, the power generated by water wheels depends upon local rains as the storage may be only sufficient for a few days. The largest amount of power in the above-mentioned plants is obtained in the spring and fall when heating is still in evidence. If more water is used and the engine which is doing the heating (or should be) carries a lighter load with a corresponding saving of steam, it becomes necessary to by-pass live steam to the heating system and this ruins the economy we had hoped for.

Among our readers are many young men who are perhaps for the first time in charge of a plant. They will see the great advantages to be derived from using water power and may advise their employers to install larger hydro units at perhaps a prohibitive figure.

Water power is figured along the same lines as steam power: i. e.—33,000 ft.-lb. per minute constitute a horsepower. The amount of water in pounds per minute times the mean head divided by 33,000 will give the theoretical horsepower and this figure times the percentage efficiency will give the actual horsepower.

The engineer with a water supply that has a very low head will be surprised to see how many hundreds of thousands of gallons of water it takes to generate a little horsepower. For instance, companies that sell water power ordinarily use the term mill power. A mill power is 85 bona fide horsepower at 100 per cent efficiency. If the installation is a trifle antique 70 per cent efficiency is allowable. This cuts down the original figure of 85 hp. to 60 hp. and represents 30 cu. ft. of water under a 25-ft. head being consumed every second.

This quantity of water in gallons per minute would approximate 13,500, or 800,000 per hour; and this, remember, is only 60 hp. Where a large quantity of mechanical power is in demand and steam is used very sparingly in the process, water power is an advantage, but it is a paying proposition to obtain a good head so that the amount of water used will be less, and it must be remembered that for good economy the water must slide from the hydraulic rotor with all possible freedom, just as steam must slide from the blades of a steam turbine, because velocity is power in both cases.

The writer has had years of experience in reclaiming almost disused water privileges and is of the opinion that some water rights have been salvaged that never paid a fair interest on the investment. It is to be understood that this article does not refer to large developments but to the small or medium mill or factory installation.

In my present plant, I have experimented with our water power, which is something over 3000 hp., and on the night shift when steam consumption exceeds mechanical output, we positively are out the price paid for water if we operate wheels.

Our engine, which operates nights, is a twin 30 by 60 in. and the steam is all consumed in the process. Why pay for water power and use live steam?

Two English Engines

UNIFLOW AND LOCOMOBILE TYPES MADE BY MESSRS. ROBEY AND CO., LIMITED, OF LINCOLN

IT HAS long been recognized that when steam is carried through a large range of expansion in a single-cylinder engine of the ordinary type, the temperature changes within the cylinder constitute a serious source of loss. If, for example, steam is admitted at a pressure of 180 lb. per square inch and exhausted at a vacuum of 26 in., the temperature will drop during expansion from about 373 deg. F. to 126 deg. F., with a corresponding cooling of the walls of the cylinder. The incoming steam during the next stroke has to flow through valves and ports into a cylinder, all of which a second before were in contact with comparatively cold steam exhausting after the previous stroke. The metallic surfaces thus become re-heated at the expense of the incoming steam, much of which becomes condensed in the process. This interchange of heat takes place at every stroke of the engine, and is responsible for a material loss. The provision of separate steam and exhaust valves mitigates, to a certain extent, the loss from initial condensation, but even with such an arrangement there is considerable waste of heat from the cause we have mentioned. Compound and triple expansion engines owe their greater economy entirely to their ability to utilize a large range of expansion without heavy condensation losses owing to their smaller temperature ranges per cylinder, but the greater cost and complications of such engines, as compared with simple engines, have also to be taken into account. A compound or triple expansion engine, of course, gives no more power than would be obtained from the same amount of steam expanding in its low-pressure cylinder, the provision of high-pressure and intermediate cylinders adding nothing to the power of an engine, but only enabling the expansion of the steam to be carried out with less loss than in a single cylinder. It follows that if a single-cylinder engine could be devised which would avoid the heat losses inherent in the ordinary type it could compete in economy with the compound or triple-expansion engine, and would have substantial advantages over such engines in respect of simplicity of construction.

In the Uniflow engine, of which Messrs. Robey and Co. are the largest British manufacturers, the whole range of expansion of the steam from boiler pressure to condenser pressure is carried out in a single cylinder. The cylinder is longer than the usual proportions, and the piston is nearly half the length of the cylinder. Steam is admitted by drop valves placed at the ends of the cylinder and is exhausted through a ring of ports around the center of the cylinder which are uncovered by the piston as the latter approaches the end of each stroke. There are thus no exhaust valves at all, the motion of the piston controlling the opening and closing of the exhaust ports. The hot live steam entering the cylinder cannot approach anywhere near these comparatively cold ports or reach the cooled cylinder walls adjoining them, as the piston covers all the cooled area. Further, the exhaust steam does not flow over or near the hot inlet valves and ports, so that the latter suffer the minimum of cooling as the temperature of the working steam is reduced by expansion. It will therefore be seen that, so far as possible in a reciprocating engine, a steady temperature gradient exists within the cylinder with a consequent minimum loss due to the interchange of heat between the steam and the metallic surfaces. This permits of a large ratio of expansion without undue condensation losses, and in fact a simple Uniflow engine

is claimed to equal a triple expansion engine in efficiency when working under the same steam conditions.

The mechanical simplicity of the Uniflow engine is also noticeable. The length of the piston obviates the necessity for a tail rod, so that as compared with a tandem compound Corliss or drop-valve engine, the Uniflow has one piston rod gland as against three, and two valves only as against eight. The valves are located on the top of the cylinder and are operated by cams driven by eccentrics mounted on a lay shaft. A centrifugal shaft governor varies the position of these eccentrics according to the speed of the engine, and so alters the time of cutoff. The type of valves and the general construction of the Uniflow engine render it suitable for the highest superheats which are met with in practice. It is fitted with forced lubrication to the main bearings, connecting rod and guides and in all other respects follows the best modern practice. The single-cylinder type is built for general stationary work in 18 sizes ranging from 60 to 1000 hp., but the uniflow principle has been embodied in the undertype engines with locomotive boilers, which have been for so long a specialty of Messrs. Robey and Co. The undertype uniflow engines range from 24 b.hp. to 160 b.hp. noncondensing, and from 30 b.hp. to 200 b.hp. condensing, but they possess an overload capacity of about 50 per cent which can be utilized in emergency.

Figures 1 and 2 give sections through a typical Uniflow cylinder which will be readily understood from the description we have already given. The control of the Uniflow engine is effected by a governor situated on the lay shaft, details of the governor gear being given in Figs. 3 to 5. The action of the governor is to cause the eccentric sheaves to move on the rectangular blocks shown, and thus to vary the cutoff of the steam.

The Robey Compound Superheater Engine

For situations where an extremely compact yet highly economical steam plant is required, the compound superheater engine is often advantageous. The floor space necessary is small as compared with other kinds of plant, and owing to the self-contained design the cost of foundations and other incidentals to installation is also a minimum. The absence of all steam pipes connecting the engine with the boiler not only simplifies erection in out-of-the-way places, but at the same time does away with what is often a source of considerable loss. The efficiency of engines of the type in question is, moreover, remarkably good, and this fact,

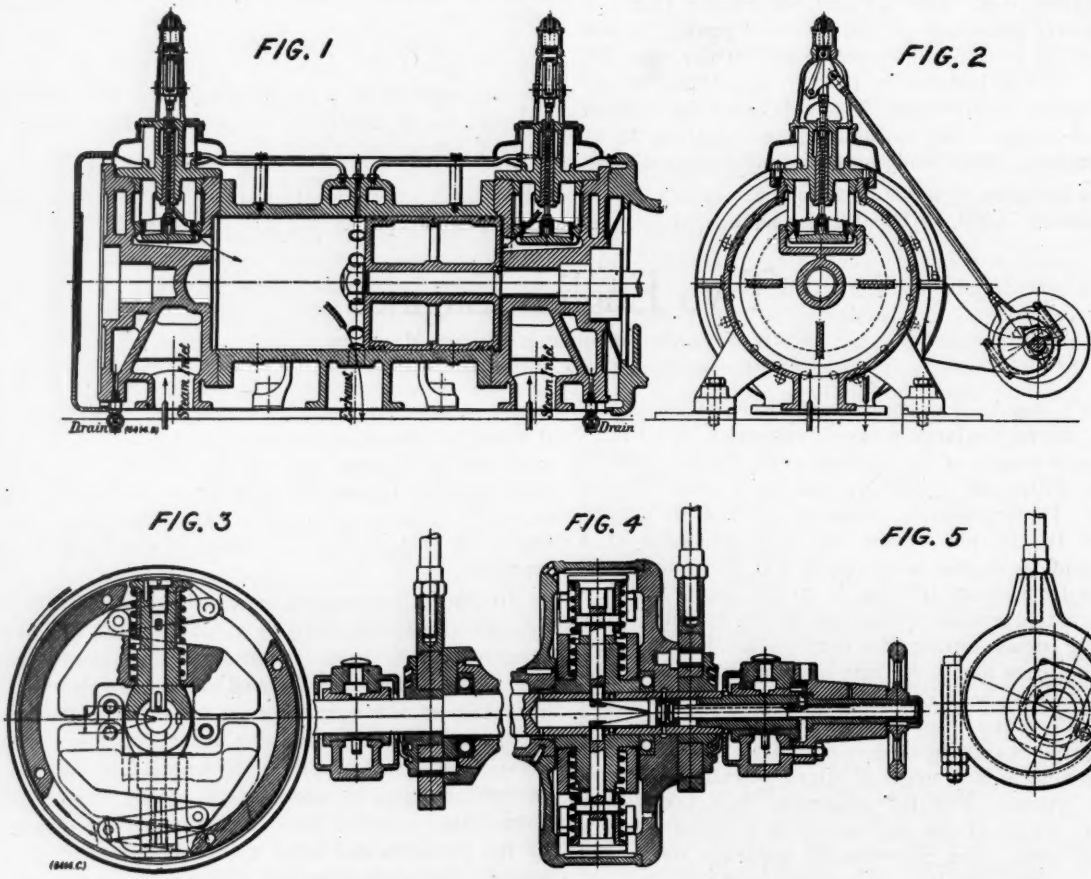


FIG. 1. HORIZONTAL SECTION THROUGH A TYPICAL UNIFLOW CYLINDER. FIG. 2. CROSS SECTION OF A TYPICAL UNIFLOW CYLINDER. FIG. 3. CROSS SECTION OF THE UNIFLOW STEAM ENGINE GOVERNOR FIG. 4. HORIZONTAL SECTION OF THE UNIFLOW STEAM ENGINE GOVERNOR. FIG. 5. ECCENTRIC AND ROD OF THE UNIFLOW STEAM ENGINE GOVERNOR

combined with the other advantages to which we have alluded, has brought about their wide adoption.

The firebox of the Robey superheater engine is of the circular corrugated type, terminating in a tube plate, from which fire tubes extend to the back tube plate at the smoke-box end of the boiler. This latter tube plate is no larger than necessary to carry the tubes, and is fastened to the inside of the end plate of the boiler shell by means of bolts. Similarly the front end of the fire-box is bolted to the front of the boiler, and so, by removing the bolts, the whole of the fire-box and tubes can be withdrawn from the boiler shell for inspection or cleaning. To do this involves no interference with the tubes themselves, nor does it require more skill than any intelligent man possesses. When the fuel to be used is of a bulky nature, such as straw, wood logs, bagasse, or stalks of cotton, maize, etc., the fire-box is extended at the front, the extension being lined with firebrick, and supported on wheels for ready removal. Furthermore, by the fitting of a stepped grate, sawdust, rice or coffee husks, tannery refuse, etc., can be used for fuel, and, as another alternative, oil burners can be fitted if desired.

The superheater consists of a large number of small diameter steel tubes arranged in a zig-zag fashion and occupying practically the whole inside of the smoke-box, one at the top and two at the bottom. The top header is divided into two parts, the steam from the stop valve entering the one nearest the chimney, passing down through two sets of the zig-zag tubes to the bottom headers and returning by other similar tubes to the inner and hotter end of the top header. It passes thence to the engine stop valve. Another valve provides for the isolation of the superheater, which can be withdrawn from the smoke-box complete when desired.

The engine proper is of the compound type, having cylinders fitted with separate liners which are forced into the main casting and bored in position. A bypass to the low-pressure cylinder enables the engine to be run as a high-pressure engine when starting under an exceptional load or in other emergency. The high-pressure cylinder is usually fitted with a piston valve on account of the high superheat with which the engine works, but Messrs. Robey and Co. also fit drop valves to the larger sizes. In any case, the engine is governed by a crankshaft governor which varies the point of cut-off in the high-pressure cylinder. The low-pressure eccentric has a hand adjustment.

When the superheater engine is arranged for condensing, as it usually is on account of the greater economy so obtained, the condenser is either of the surface or jet type according to whether the nature of the water renders the conservation of the condensed steam for boiler feed necessary or not. Before passing to the condenser or to the atmosphere, as the case may be, the exhaust steam is taken through a feed-water heater of the surface type, which raises the feed-water temperature to 170 deg. F. or so, without contaminating it with oil from the cylinders. The air pump for the condensing engines is of the double-acting central inlet type without either foot valves or bucket valves. It is driven by an eccentric on the crankshaft.

The Robey superheater engines are built as condensing engines in 15 sizes ranging in power from 40 b.hp. at 220 r.p.m. to 450 b.hp. at 160 r.p.m. The weights in the case of these sizes of engines having jet condensers range from 12 to 70 tons. In sizes above 225 b.hp. the flywheel takes the form of a rope pulley grooved for 1¾-in. ropes. In the case of non-condensing engines the power is about 25 per cent less at their most economical load. The weight is about 5 per cent less than when equipped with condensers.—Engineering.

Don't Force a Belt to Run on Pulleys

By W. F. Schaphorst

MANY millwrights make the mistake of thinking that it is perfectly proper to force a belt to stay on its pulley by any means whatever. They seem to think that as long as the belt "runs" it is all right, and is doing as much as could be expected of it.

For instance, one millwright "took a piece of old 3-in. rubber belt, pulled off one ply, wrapped it twice around the center of a wooden pulley and nailed it solidly to the pulley"; then he says, "The belt immediately took its place on the center of the pulley and stayed there."

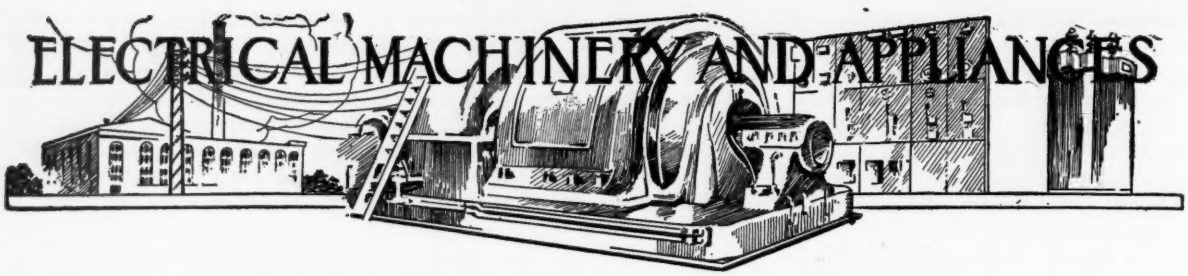
It is true that nailing a ridge of any kind of belting on a wooden pulley to increase the crown will cause the belt to move over and run on the intensified crown, even though the alinement of the pulleys may be poor; however, such a condition is hard on the belt, and if the millwright would give that side of the question some thought, he would see that if the belt has much work to do, it cannot long endure.

Let us say that the width of the belt is 6 in., and that the width of the ridge nailed on the pulley is only 3 in.; 6 in. minus 3 in. equals 3 in., which means that about 3 in. of the belt (1½ in. on each side of the center) is not in contact with the driving pulley or driven pulley at all or is in poor contact. A very intense pressure between the belt and the pulley occurs over the 3 in. of width of the ridge. In other words, 3 in. in width of the belt is compelled to do what 6 in. was intended to do.

Furthermore, with the rough face of the ridge rubbing against the equally rough face of the belt, and with the pull per square inch and the pressure per square inch doubled, it is evident that the wear on the 3-in. ridge is going to be greater than it would be on a smooth iron or smooth wooden pulley. It is quite possible that the slip is greater with the 3-in. strip than without the strip. At least, the creep is as great one way as the other. From every angle, therefore, it is obvious that nailing a ridge around the pulleys to increase the crown is poor engineering.

It is far better to aline the pulleys and shafting carefully so that the belt will run exactly as was intended by the designers of the pulleys. By using the low crown, the entire belt surface comes in contact with the pulley; the load and the wear are thus evenly distributed.

In fact, pulley coverings should not be used at all. It has been proved time and again that the natural smooth face of a metal, wooden or other pulley is far superior to any roughened face. Rough faces are too hard on the belt.



Hints on Direct Current Wiring Practice

TYPES OF SYSTEMS AND STRUCTURAL DETAILS; PRACTICAL CALCULATIONS

IN electric construction work, various types and forms of wiring exist which may be enumerated as follows:

Open or surface wiring; concealed knob and tube wiring; moulding wiring; flexible tubing or circular loom; rigid iron conduit; flexible metallic conduit; and, flexible steel armored cable. The type used is dependent upon the degree of safety required, the service to be rendered, architectural features involved and appearance of the finished job.

Other factors must of necessity be considered such as to the form of service, that is, whether of single, two or three phase, the number of conductors as two, three or four, frequency and the method of load connection utilized, that is, whether of the series, the parallel, the series-parallel or the parallel-series type.

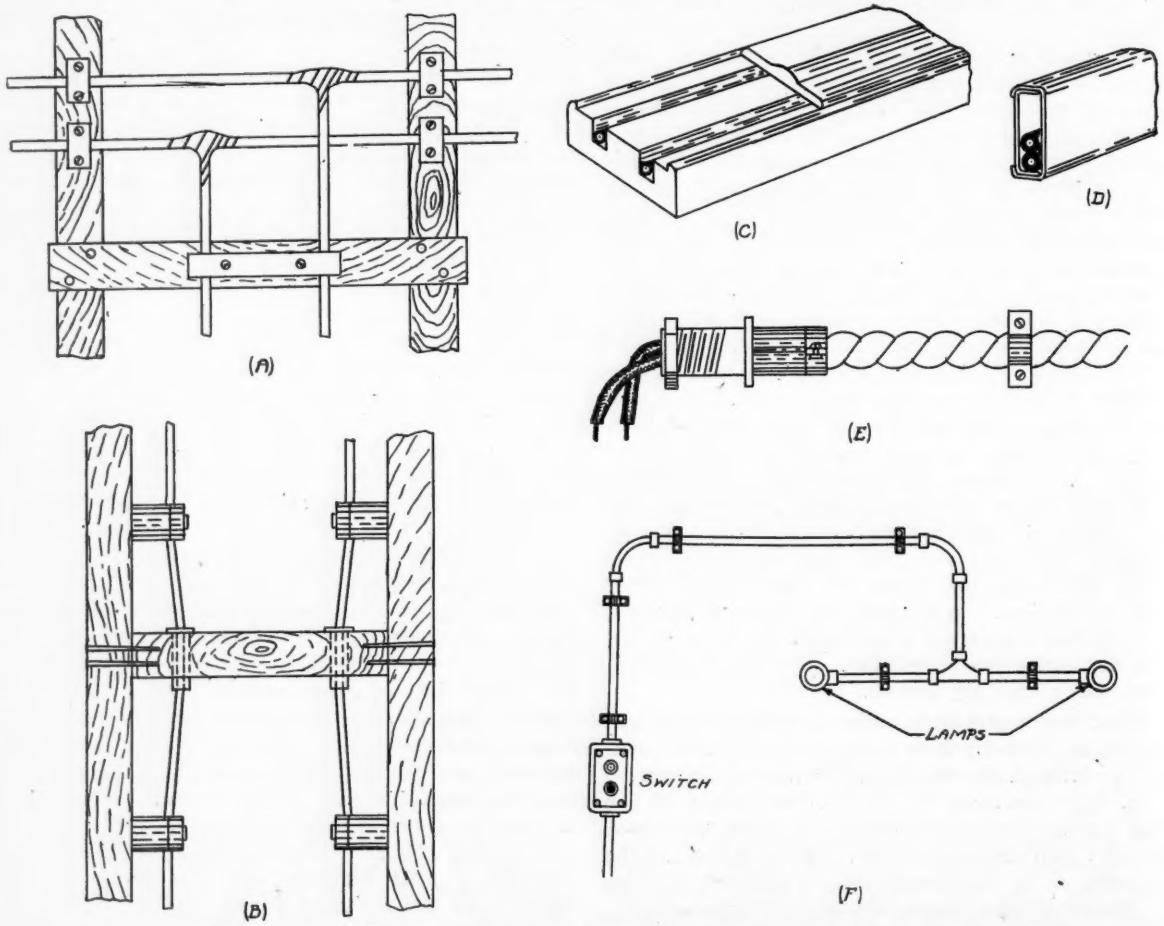


FIG. 1. (A) OPEN OR SURFACE WIRING. (B) CONCEALED KNOB AND TUBE WIRING. (C) WOODEN MOULDING WIRING. (D) METALLIC MOULDING WIRING. (E) FLEXIBLE CONDUIT WIRING. (F) RIGID CONDUIT WIRING

Where appearance is of minor importance as in mercantile establishments, factories and in industrial plants in general, the open type of wiring (see A and B, Fig. 1) as a rule proves entirely satisfactory and will meet with the requirements of the National Electrical Code if sin-

gle braid, rubber covered or slow-burning weather-proof wire is used with supports, that is holding knobs, cleats or bushings placed every 4½ ft. Exceptions to this rule are, however, permissible in the case of mill type structures where, subject to the local inspector's authorization, the wires may be supported at every beam provided no wire smaller than a No. 8 is used and 6-in. spacings are utilized. In no case is a spacing of less than 2½ in. allowed and for working voltage of from 300 to 550 v., 4 in. are insisted upon.

All connections made should be so spliced or joined as to be both mechanically and electrically secure without solder. The joints must then be soldered unless made with some form of standard splicing device, and covered with an insulation equal to that on the conductors. Stranded wires (except in flexible cords) must be soldered before being fastened under clamps or binding screws, and whether stranded or solid, when they

B. & S. Gage Number	Diam. of Solid Wire in Mils	Area in Circular Mils	Rubber Insulat'n Amperes	Other Insulat'n Amperes
18....	40.3....	1,624....	3....	5
16....	50.8....	2,583....	6....	10
14....	64.1....	4,107....	15....	20
12....	80.8....	6,530....	20....	25
10....	101.9....	10,380....	25....	30
8....	128.5....	16,510....	35....	50
6....	162.0....	26,250....	50....	70
5....	181.9....	33,100....	55....	80
4....	204.3....	41,740....	70....	90
3....	229.4....	52,630....	80....	100
2....	257.6....	66,370....	90....	125
1....	289.3....	83,690....	100....	150
0....	325.	105,500....	125....	200
00....	364.8....	133,100....	150....	225
000....	409.6....	167,800....	175....	275
		200,000....	200....	300
0000....	460.	211,600....	225....	325
		250,000....	240....	350
		300,000....	275....	400
		350,000....	300....	450
		400,000....	325....	500
		500,000....	400....	600
		600,000....	450....	680
		700,000....	500....	760
		800,000....	550....	840
		900,000....	600....	920
		1,000,000....	650....	1,000

TABLE I. SAFE CARRYING CAPACITIES OF VARIOUS SIZES OF CONDUCTORS WITH RUBBER AND OTHER INSULATION

have a conductivity greater than that of No. 8 must be soldered into lugs for all terminal connections, except where a standard solderless terminal connection is used.

Knob and tube wiring of the form indicated at B, Fig. 1, was formerly and still is quite extensively employed (except in localities where local ordinances prohibit such practice) in concealed work in frame buildings.

In placing interior conductors only those of such size should be used as will with safety carry the maximum amount of current flow expected. In Table I is given the safe current-carrying capacities of the various sizes of conductors with rubber and with other insulation.

For low voltage work particularly where only extensions of short length are to be made and where the cost of installing concealed wiring would prove prohibitive, moulding of either wood or metal, as illustrated at C and D, Fig. 1, is frequently employed. Single-braided rubber-covered wire may be used in moulding work, but according to Code requirements joints and splices must be avoided except at outlets and fittings.

Size B. & S.	One conductor in a conduit. Electrical Trade Size	Two conductors in a conduit. Electrical Trade Size	Three conductors in a conduit. Electrical Trade Size	Four conductors in a conduit. Electrical Trade Size
*14	½	½	½	½
*12	½	½	½	¾
*10	½	¾	¾	1
* 8	½	1	1	1
6	¾	1	1	1¼
5	¾	1¼	1¼	1¼
4	¾	1¼	1¼	1¼
3	¾	1¼	1¼	1½
2	¾	1¼	1½	1½
1	¾	1½	1½	2
0	1	1½	2	2
00	1	2	2	2½
000	1	2	2	2½
0000	1¼	2	2½	2½
CM				
200000	1¼	2	2½	2½
250000	1¼	2½	2½	3
300000	1¼	2½	2½	3
400000	1¼	3	3	3½
500000	1½	3	3	3½
600000	1½	3	3½	
700000	2	3½	3½	
800000	2	3½	4	
900000	2	3½	4	
1000000	2	4	4	
1250000	2½	4½	4½	
1500000	2½	4½	5	
1750000	3	5	5	
2000000	3	5	6	
*Single Conductor, Single Braid, Solid Wires Only (This table is not to be used for double braid wires, twin or duplex wires or stranded wires.)				
14	½	½	½	½
12	½	½	½	¾
10	½	¾	¾	1
8	½	¾	¾	1

TABLE II. CONDUIT REQUIRED FOR VARIOUS SIZES OF CONDUCTORS IN COMMERCIAL USE

When carrying alternating currents, all of the conductors composing the circuit must be carried in a single metal moulding if the detrimental effects of inductance are to be avoided.

Iron Conduit

This may be either of the rigid or flexible type depending upon the form of construction employed and service requirements. The former, which is practically iron pipe provided with a coating of zinc or black enamel, is permissible for all forms of exposed and concealed wiring when carrying conductors covered with rubber and reinforced with double braiding. As in the case of moulding work, all wires must be continuous (without splicing) from outlet to outlet, and in alternating-current work but one conduit can be used for all of the conductors composing the circuit.

Table II indicates the conduit sizes required for the various sizes of conductors and cables in commercial use.

Flexible metallic conduit is particularly well suited for use when wiring finished buildings, for installations

in which the runs change in direction frequently and where movable machinery is to be served with electric energy. It is available in lengths of from 25 to 250 ft., depending upon its size.

Steel Armored Conductors

Flexible steel armored conductors are built up of rubber insulated wire or cable which may or may not be covered with lead sheathing, depending upon service requirements, and the whole wrapped with two layers of spirally wound flexible steel armor. Because of its substantial construction, it is applicable for work in

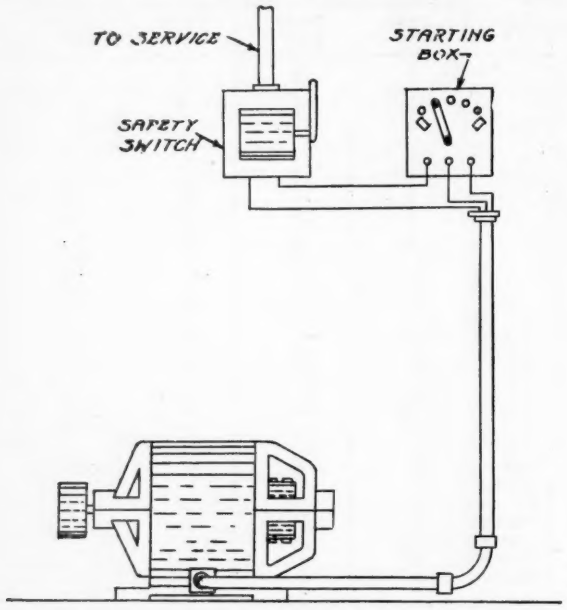


FIG. 2. METHOD OF USING RIGID CONDUIT IN CONNECTION WITH MOTOR WORK

finished structures and may without fear of damage be brought into contact with steel work, piping, etc.

Conduit Fittings

In order to secure uniformity of construction many special fittings not otherwise required are necessary for use in connection with conduit work. Where electric service enters a building for aerial lines some form of goose neck, either a special member or one made up of conduit and fitted with porcelain entrance openings, are used. The leads are then carried through either rigid or flexible conduit to a cut-out switch and fuse and the meter, all of which, together with the distribution board, may be enclosed in a steel cabinet. Distribution leads are placed in conduits to the local distribution cabinets or switches or directly to the load as the case may be.

Special forms of outlet boxes designed to meet the requirements of particular forms of construction and service are available. They generally are of pressed sheet metal of the forms shown in Fig. 4, and have entrance and exit openings for the reception of the conduit which is held in place by means of suitable locknuts. Provision is also made for the attachment of such fittings as receptacles, switches, etc. Where motors are served, these are fitted with terminal boxes as indicated in Fig. 2.

Wiring Calculations

When at a temperature of 75 deg. F. a 1-ft. length of commercial copper wire with a cross-sectional area of one circular mil has a resistance of 10.8 ohms. It is therefore evident, remembering that the resistance of a conductor varies directly as its length and inversely as its cross-sectional area, that the resistance of a conductor of such wire may be readily determined by dividing the product of 10.8 and its length in feet, by its cross-sectional area in circular mils. Or expressed as a formula, we have

$$R = (10.8 \times L) \div C.M. \quad \ldots\ldots (1)$$

where R is the resistance in ohms, L the length of the conductor in feet and C.M. the cross-sectional area in circular mils.

The product of the resistance of a conductor in ohms and the current flow in amperes provides as a result the voltage drop. Multiplying, therefore, each side of the above equation by I, the current flow in amperes, we have

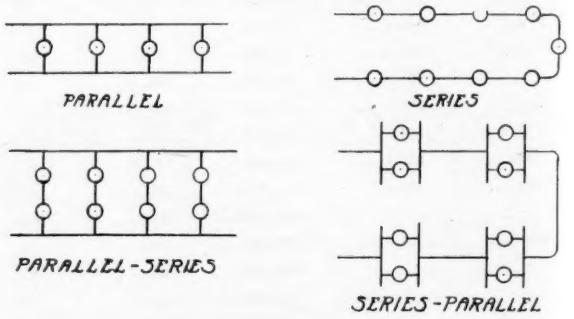
$$I\,R = I(10.8 \times L) \div C.M. \quad \ldots\ldots (2)$$

or

$$e = I(10.8 \times L) \div C.M. \quad \ldots\ldots (3)$$

in which e is the drop in volts.

Therefore, with a knowledge of the maximum amount of current in amperes to be carried, the length of the conductors in feet and the allowable voltage drop trans-



THE SYMBOL -o- INDICATES LAMP OR OTHER CURRENT-CONSUMING DEVICE

FIG. 3. DIAGRAMMATIC SCHEMES OF PARALLEL, SERIES, SERIES-PARALLEL AND PARALLEL-SERIES LOAD CONNECTIONS

position of formula (3) will provide a ready means for the determination of conductor size for any two-wire, direct-current circuit. We then have

$$C.M. = I(10.8 \times L) \div e \quad \ldots\ldots (4)$$

Should it be preferable to use the distance from the point of energy delivery to the center of load or distribution $L \div 2$ is used instead of L so that formula (4) becomes:

$$C.M. = I(10.8 \times L) \div 2e \quad \ldots\ldots (5)$$

To insure compliance with Code requirements, however, a comparison should be made with a table showing the maximum safe carrying capacity of various sized conductors fitted with rubber and other insulation. Should the size of the conductor, as determined by the above formulas, be found smaller than that required by

the Code, that size specified by the Code should preferably be used.

On lighting circuits, a drop of from 1 to 3 per cent of the receiver voltage is allowable, while in motor circuits these may vary from 5 to 10 per cent or even slightly more.

Three-Wire, Direct-Current Calculations

As in practice three-wire direct-current circuits are ordinarily designed under the assumption that the system is balanced, either formulas (4) or (5) may be employed to compute the conductor size required for such a system. Due, however, to the fact that two groups of receivers are connected in series, the total drop in voltage is the sum of the drop in the two outside lines and twice that occurring in each receiver group.

National Electrical Code specifications require the neutral line to be of the same size as that of each of the outside conductors.

For a two-wire circuit, we have found the conductor size in circular mils [formula (5)] equals $I(10.8 \times L) \div 2e$. By allowing a voltage drop in a three-wire system twice that of a two-wire system of equivalent capacity, we have

$$C.M. = I(10.8 \times L) \div 2 \times 2e \text{ or } C.M. = I(10.8 \times L) \div 4e. \quad (6)$$

thus indicating that in a three-wire system each of the outside conductor has a sectional area of but half that of each of those of a two-wire system or, in other words, but 50 per cent of the copper is required, that under the assumption no neutral is employed. With neutral conductor, however, which, as stated, is to be of the same size as each of the outside lines, another 50 per cent of the copper of the outside lines of the three-wire system, or 25 per cent of the total copper of an equivalent two-wire system and as three conductors of like size are of the two outside conductors of a three-wire system constitutes but 25 per cent of the total copper of a two-wire system and as a three conductors of like size are employed in three-wire work, the total copper of a three-wire system is but three times 25, or 75 per cent of that of an equivalent two-wire system.

Loss of Power

In any electrical conductor regardless of the material of which it is composed, a drop in voltage, e, is bound to occur. This voltage drop is dependent in value upon the resistance of the conductor in ohms and the current flow in amperes and may readily be represented by the formula $e = R\,I$ wherein R is the resistance and I the current. The total power in an electric circuit expressed in watts is equal to the product of the applied voltage E and the current flow I, or E I. That, however, not usefully employed or, in other words, that lost, is equal to the product of e and I, and as e as above shown is equal to R I, the loss in watts may be expressed by the product of I and RI, or RI^2.

Again, we have found that e [refer to formula (3)] is equal to $I(10.8 \times L) \div C.M.$, so that we may also express the loss as

$$eI = I^2(10.8 \times L) \div C.M. \ldots\ldots (7)$$

obtained by multiplying both sides of the equation of formula (3) by I.

Economic Considerations of Wiring

Frequently those in charge of electrical construction will install conductors of such size as to provide a negligible voltage drop and line loss, believing that by so doing a maximum degree of economy may be obtained. From a purely engineering standpoint, such procedure may be well and good; but from a financial consideration, desirable conductor sizes are limited as explained by the Law of Lord Kelvin and which, as modified by Kapp, reads as follows: "The most economical area of conductor is that for which the annual cost of energy wasted is equal to the interest on that portion of the capital outlay which can be considered proportional to the weight of copper used."

The practical side of this law may be best understood by referring to its discussion by Franklin and Estey in their Elements of Electrical Engineering. These authorities state that "the original cost of erection of a distribution line consists of two nearly independent parts, namely (a) the cost of the copper and (b) the cost of poles, cross arms, pins and insulators and the cost of erection. That is to say, even if we were to double the size of wires to be used, the cost of item (b) would not be increased to any considerable extent. The disadvantage of using large wires lies. therefore, almost wholly in the annual charge, including interest

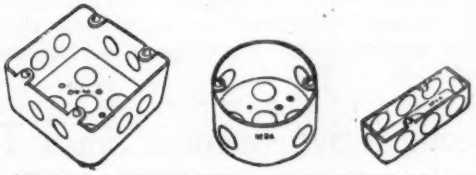


FIG. 4. TYPICAL OUTLET BOXES USED IN CONNECTION WITH CONDUIT WORK

on the cost of the wire, depreciation of the wire, and taxes. The advantage of using large wires, on the other hand, lies in the decreased loss of power in the wires. Therefore, the most economical size of wire is that for which the additional annual charge on a large wire would exceed the annual value of the power saved by the use of the larger wire, or, in other words, the most economical size of wire is that for which the sum of the annual charge in the total copper plus the annual value of the power lost in the wires is a minimum. The annual charge may be estimated at, interest 5 per cent, depreciation 3 per cent, and taxes 1½ per cent.

"The economic balance between loss of power and cost of copper always leads to a definite number of circular mils of sectional area of wire per ampere of current without regard to the voltage to the distance of transmission.

"Electric power is to be supplied for h hours to a customer. The cost of power at the switchboard is p dollars per kilowatt-hour, the cost of copper is c dollars per pound and the depreciation and the charges is t per cent per annum. It is required to find the sectional area of the copper wire in circular mils per ampere of current or the condition that any increase in the amount of copper would effect a saving of power of which the annual value would be less than the interest on the cost of the additional copper. Let 2 l be the length of the wire in feet, C.M. its sectional area in circular mils, R its resistance in ohms, W its weight in pounds and I the

current in amperes. Then $R = (10.8 \times 2\,l) \div C.M.$ so that the lost power in kilowatts is $\frac{21.6 \times l}{1000 \times C.M.} I^2$ and the annual loss of energy is $\frac{21.6 \times l}{1000 \times C.M.} I^2 p\,h$ dollars per year. On the other hand, $W = 0.000,003,03 \times 2\,l\,C.M.$ pounds, of which the cost is $0.000,006,06\,l\,C.M.\,c$ dollars, the interest on this cost is $0.000,000,060,6\,l\,C.M.\,c\,t$ dollars per year and the quantity to be made a minimum by choosing C.M. is $\frac{21.6 \times l}{1000 \times C.M.}$ $I^2 p\,h + 0.000,000,060,6\,l\,C.M.\,c\,t$. Differentiating this expression with respect to C.M. and placing the differential coefficient equal to zero gives:

$$-\frac{21.6 \times l}{1000 \times C.M.} I^2\,p\,h + 0.000,000,060,6\,l\,c\,t = 0$$

from which l cancels out and we find:

$$\frac{3}{I} = \text{circular mils per ampere} = 597\sqrt{\frac{ph}{ct}}$$

or

$$C.M. = 597\,I\sqrt{\frac{ph}{ct}} \quad \ldots\ldots\ldots\ldots (8)$$

While the application and use of this theory will many times result in the saving of considerable money, it should not be employed as a governing factor, but rather subordinate to the rulings of the National Electrical Code.

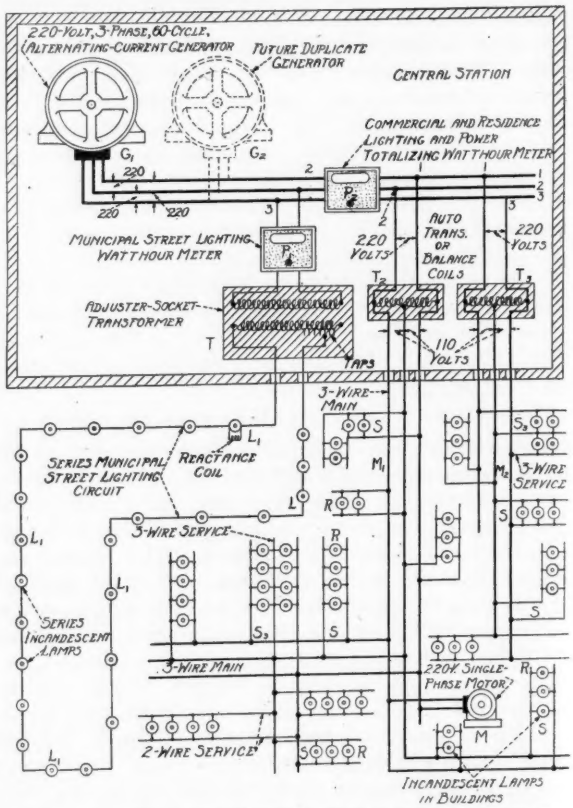
Electrical System for a Small Town

By C. A. Rosse

FOR electric-lighting systems for small towns, the distribution scheme shown diagrammatically herewith is very satisfactory. It is applicable for the average community of a thousand, or fewer inhabitants. The generators (G_1 and G_2) are the 220-v. three-phase, 60-cycle machines which are standard with a number of the manufacturers. An "adjuster-socket" series-tungsten-lamp street-lighting system is used. This is served through an adjuster-socket transformer, T_1. The commercial-and-residence incandescent lighting mains are single-phase, three-wire, 110-220-v. The three-wire voltages are provided by balance coils T_2 and T_3, connected as suggested. The energy consumption for street lighting and for commercial and residence lighting is registered separately on watthour meters P_1 and P_2.

A system laid out as suggested is very flexible. It provides amply for expansion for future growth. If the town is, ultimately, served by a long-distance transmission line, it will not be necessary to alter the distribution system, if it is designed in accordance with the plan detailed in the diagram. Furthermore, if the load on the plant becomes sufficiently great that generation at 2200 v. is justified, then the existing distribution system can be used as it is, by feeding it through new 2200-to-110-220-v. transformers served by new 220-v. feeders. The diagram indicates merely the general characteristics of the proposed arrangement. No attempt has been made to portray the fuses, switches and electrical-measuring instruments which will be necessary for the proper control and operation of the installation. If the load becomes too great for the first generator, G_1, a duplicate G_2, may be added.

Each street light, L_1, is a series incandescent lamp shunted with the customary reactance coil. Two-wire services are indicated by S and three-wire services by S_3. The 110-v. incandescent lamps in the buildings are indicated by R. M_1 and M_2 are the three-wire mains. A 220-v. single-phase motor can be served as shown at M.



DIAGRAMMATIC LAYOUT FOR A SMALL TOWN CENTRAL STATION

In connecting the load to the circuits, it should, insofar as is possible, be balanced between each of the three phases of the three-phase mains. Considerable unbalance will not, however, cause unsatisfactory operation.

How Little They Realize

THE PRESIDENT of the corporation had made his semi-yearly inspection of the plant and upon his return to the office said to the chief:

"Mr. Warren, with one exception, I'm very well pleased with the condition of the plant."

"And what is that, sir?"

"At the rear of the boiler house is a large, unsightly pile of dirt which I want removed at once. It detracts from the otherwise spick and span appearance of the plant."

"I'm afraid we cannot very well do that, sir."

"And why not?" angrily asked the president.

"That pile of dirt is our only means of operation, in other words, our coal supply."

Improper Oil Clogs Refrigerating Plant

TROUBLE WITH REFRIGERATING MACHINERY AT COLD STORAGE PLANT DUE TO USE OF IMPROPER OIL ON COMPRESSOR ROD. BY C. E. ANDERSON

THE manager of a cold storage plant called me up one day, requesting me to call at their plant and see if I could help them out, as they were in trouble. I visited the plant the next day and interviewed the chief engineer regarding their plant troubles.

The chief engineer informed me that the plant had been losing capacity every day since they started up in the spring, and he could not account for it. The last few days before I called they could not get any frost on the pipes in the coolers. The temperature had climbed up to 38 deg. and they were in danger of losing the products stored.

During these last few days, when they operated the compressor, the condensing pressure slowly climbed up to 250 lb. When it reached this point, they shut down the compressor and allowed it to stand for some time, then purged the condensers of air and started up again. This performance was repeated several times without any results in the coolers.

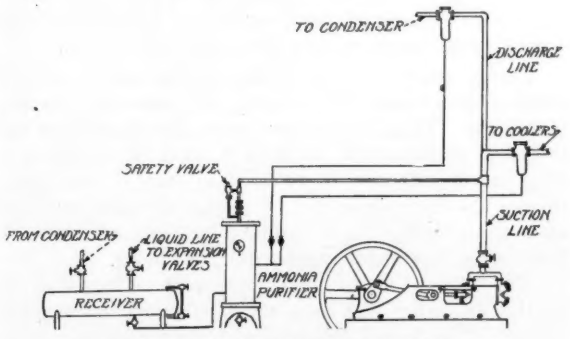


FIG. 1. APPARATUS IN ENGINE ROOM

I suspected that the expansion valves were plugged up, so we commenced to pump a vacuum on the evaporator coils, or the low side of the plant, in order to remove the bonnets of the expansion valves and examine them.

When we commenced to pump down, the suction gage registered 8 lb. After pumping 3 hr. the gage registered 2 lb. and the condensing pressure was up to 245 lb. I suspected the gage was not indicating correctly. We disconnected it, and found, by holding our fingers over the opening in the gage line and opening the gage line valve, that we had a vacuum on the low pressure side of the system.

The expansion valve bonnets in the coolers were next removed, and the valve and seats examined. These were all found slightly oily, but otherwise clean and free from obstructions of any kind. We replaced them. While this was being done, I had to do some quick thinking as to what to do and where next to look for the trouble.

There was a sufficient charge of ammonia in the system, in fact the liquid receiver was full and plenty of pressure behind it, so there was only one conclusion I could come to, which was that the liquid line was plugged somewhere between the main liquid valve on the receiver and the expansion valves in the coolers.

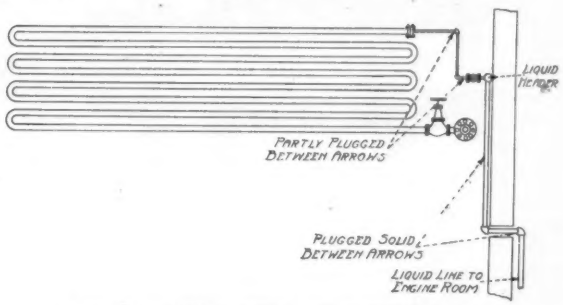


FIG. 2. COOLER COILS AND CONNECTIONS

I went around the coolers to see that all the bonnets were placed back on the expansion valves and bolted up. After making sure of this I went down in the engine room and opened the main liquid valve (between the liquid receiver and liquid line to coolers) for a few seconds, and returned to the coolers and loosened the bonnet of the expansion valve nearest the main liquid line, to see if there was any ammonia in the line. There was not even a smell of ammonia. My conclusion seemed correct—there must be an obstruction in the liquid line some place between the receiver and the expansion valves, otherwise there would be signs of liquid ammonia at the expansion valve.

There was only one thing to do—take down the liquid line, piece by piece, from the receiver to the expansion valves and examine it for obstructions or plugs of any kind.

We started a fitter and helper at each end of the line and worked towards the center. About the third or fourth section of pipe we took down (from the cooler end) we found the trouble. This pipe was plugged entirely from end to end, with a sticky, oily mass, somewhat resembling what molasses and sand mixed to a

thick paste would look like. The next two sections of pipe were the same. The next section was practically clear, in fact the rest of the liquid line, from where it entered into the cooler to the receiver, was clear of any dirt or obstructions, but very oily. We melted the oil and grit out of the piping by means of a steam jet. One section of pipe we could not melt out with steam, but we had to heat it in the furnace of the boiler, in order to remove the grit. We finally cleared the piping and connected it up again and started the plant.

Everything seemed O. K. for awhile, then the back pressure started to climb up. We kept cutting down on the expansion valves until they were barely cracked open, but the back pressure was still above normal and did not seem to come down. This condition pointed out to us that the compressor was not pumping properly, so this was the next apparatus to receive our attention.

We removed the valve bonnet on one of the suction valves and found it very oily and working stiff. We removed all the valves of the compressor and found them in a very bad state. The discharge valves were completely gummed up with hard burnt oil, in fact so full of this material that the valves would not function properly. They would open and remain so for a period, while the suction valve on one end of the cylinder would

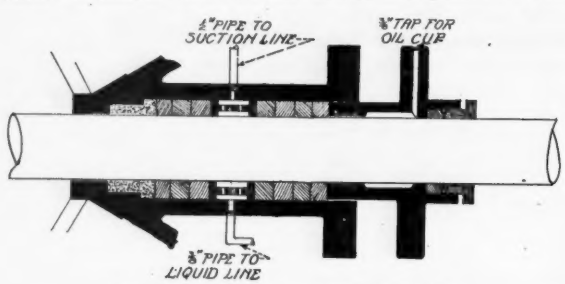


FIG. 3. DETAILS OF STUFFING-BOX

only open about 25 per cent of its normal travel. We cleaned these valves with gasoline thoroughly and replaced them in the compressor. We did not have time to remove the heads from the compressor to clean the cylinders and piston, but cleaned out as much of this gum as we could through the valve ports by means of waste and gasoline.

We started up again, feeling rather sure that we had found all the trouble. This time the back pressure went down as it ought to, showing that the compressor was working properly. We increased the opening of the expansion valves right along, but the back pressure kept on dropping, in fact it reached a vacuum and we had the expansion valves open about one and one-half turns. The first pipe of the coils in the cooler was frosted about 20 ft. and there it stopped, which showed us we were not getting ammonia into the coils in a sufficient quantity. The cooling coils were connected to the expansion valve by a ½-in. line, with two ells in the rim, as indicated in the sketch, and I noticed that there were no signs of frost on this line, from the expansion valve to about the center of the first vertical section of this line, in fact all the connections from the expansion valves to the different coils in the cooler showed about the same symptoms. These lines were partially obstructed. Of this there was no doubt. We pumped a vacuum on the low side again and removed the feed lines from the expansion valves to the coils, and found them full, or nearly so, of the same gummy material. There was a slight opening through the center, just about large enough to pass a No. 14 wire through. That is all the opening they had. This accounted for the peculiar frost line, as the ammonia did not expand until it passed the obstruction in these lines.

After cleaning out these connections, and replacing them, we started up again, wondering what we would find next. We were ready for anything, but nothing happened. Everything ran all right—the pipe coils frosted over the coolers nicely and in 2 hr. we had the coolers down to the proper temperature.

Next day we made an investigation, to ascertain the cause of this gumming material in the system. It did not take long to find it. They were using red engine oil on the ammonia compressor rod, instead of a non-congealing oil of the zero type. The compressor was of the horizontal type, equipped with an oil pump for circulating oil through the lantern in the stuffing-box. Readers can imagine a compressor working on a vacuum half the time, with this type of lubrication, that it would not take long to fill the system with oil.

The chief informed me that he had used this oil on the recommendation of a friend. Neither he nor his friend, investigation revealed, had ever operated an ammonia compressor any length of time, and thought any old oil would do. He kept records of oil used, and they showed that there was about 70 gal. of oil somewhere in that system. Pretty good dose for a 100-t. system.

We removed the oil pump and placed a one pint oil cup on the gland of the stuffing-box and fed about four drops of zero oil per minute on the rod, which proved quite sufficient. We also connected the oil hole on the top of the stuffing-box, over the lantern, to the suction line, by means of ½-in. piping, with a valve in this line. This relieved some of the pressure on the packing and helped considerably to keep the rod running cool.

On the opposite side of the stuffing-box, or on the bottom, underneath the lantern, we connected another ⅜-in. line. This line we ran to the liquid receiver and installed an expansion valve in it, near the compressor. This line is intended to be used in case of emergency, to cool the compressor rod, by means of injecting liquid ammonia directly on it through the lantern. We also installed a home-made regenerator, as shown.

The bottom of the oil interceptors or traps on the suction and discharge lines were connected to the regenerator. The liquid receiver was connected to the regenerator, by means of a 1-in. line, from the bottom of the receiver to the regenerator.

We made it a rule to blow down the traps to the regenerator once every watch (8 hr.). The liquid receiver was blown down 1 in. or so every watch. The first day's operation of the regenerator we removed nine gallons of oil.

This system will have to be thoroughly blown out with steam and air as soon as weather conditions permit, in order to remove the congealed oil in the cooler coils.

The coils in the coolers, no doubt, contain a film of this oil from one end to the other, and the only way to remove same is by means of steam, blown through the coils, followed by warm air, to remove the moisture from the coils, due to the partial condensing of steam.

The air in the condenser, mentioned in the first part of this article, no doubt was drawn in through the stuffing-box, as the compressor was operating on a vacuum most of the time, due to a faulty gage and insufficient feed of ammonia. It was necessary to operate with a slack stuffing-box, as the packing could not be kept tight on account of heating the rod to the danger point.

Suggestions for Conserving Ammonia

By C. T. Baker

PROBABLY one of the most serious situations affecting the operation of ice and cold storage plants at this time is the question of ammonia supply. The present indications are that the supply in the near future will be more uncertain and higher in price than it has been in the past and this being true, it is evident that unless the supply available is economically used we may shortly face an ammonia shortage that will seriously cripple the ice industry and may mean a total, or at least a partial shut-down of many plants.

Owing to the peculiar and favorable properties of liquid anhydrous ammonia as a refrigerating medium and the comparative ease at which it can be handled under widely different conditions of operation, it is not likely that a substitute will be found in the near future that may be depended upon to take the place of ammonia. Consequently, it should be evident to all users of this commodity that only by the most rigid economy of operation may we expect to be able to tide over the grave situation now facing the industry as a whole.

Source of Ammonia Loss

The source of ammonia losses in ice and cold storage plants are many, varying somewhat with the type of plant, local water conditions, etc., but generally in a well designed and well built plant it should be possible systematically to follow up ammonia joints and connections in the piping system and condensers by regular and frequent inspections in such a manner as to keep the losses from this source at a minimum.

For testing joints external to brine tanks and condensers the sulphur test is most reliable and will indicate quickly whether or not a leak exists.

For brine solutions and water run off from ammonia condensers and compressor jackets, either the litmus paper or Nessler's solution will indicate whether or not a leak is present. A properly made up Nessler's solution is doubtless the most sensible and reliable test that can be made when testing for leaks in either brine solutions or water and a supply of this solution should be kept on hand.

When testing for leaks in cold storage rooms where sulphur can not be used on account of possible damage to certain stored products, some other method must be resorted to and this may require an inspection of each individual joint and testing with dampened litmus paper.

Compressor Stuffing-Box Losses

Doubtless one of the greatest sources of ammonia loss is the ammonia compressor stuffing. Comparatively few engineers appear to realize this fact and the necessity of watching the stuffing-box and keeping the rods and rod packing in shape.

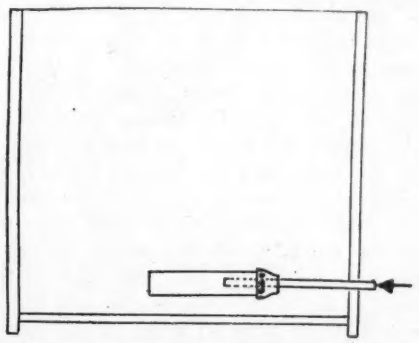
Of course, in some plants where conditions frequently change as regards suction pressure, dry to wet gas operation, or vice versa, it is next to impossible entirely to prevent leakage around the compressor rods; but, on the other hand, every precaution should be taken to insure that this loss be held at a minimum. For instance, keep the compressor crosshead shoes adjusted so as to insure the rod running true and in the center of the stuffing-box, and if the rods are cut or scored, don't delay any longer than necessary in getting them trued up.

Shoulders worn on compressor rods by hard dry packing will always be a source of ammonia leakage and this condition should be guarded against. Nothing but the best grade of rod packing should be used and when installed it should be well lubricated and well cared for generally. Undoubtedly one of the best remedies for a leaking stuffing-box is a high grade metallic ammonia rod packing.

If the rod is properly centered up, is smooth and in otherwise good condition, it will generally be a good investment to fit it up with a high grade metallic packing as such packing will usually remain tight regardless of temperature changes and stuffing gland adjustment is seldom if ever necessary.—Refrigeration.

Homemade Hot Water Heater

During the past winter we made some changes in our plant during which time our regular hot water tank heaters were out of service and we suddenly found ourselves in need of a lot of hot water for barrel washing without any facilities for heating. We endeavored to locate an ejector type of heater in the local supply house, but they were out of them, so we rigged up a jet heater of our own which nicely served the purpose. As shown



SHOWING USE OF STEAM EJECTOR TO HEAT WATER

in attached sketch, we took a 1 by 3-in. reducer fitting, screwed it up on a 1-in. steam pipe so that the 1-in. pipe end was about 4 in. beyond the fitting. The fitting had previously been drilled with ¼-in. holes, as shown. We then screwed onto the fitting a piece of 3-in. pipe about 12 in. long and we found we had a good jet heater which heated the water nicely and tided us over until the big heaters were in service again.—R. E. P., in Refrigerating World.

"Exaggeration defeats its own purpose by creating distrust."

Quarter Box Pounds and Heats

In Fig. 1 is a form of housing of an outport bearing on a 300-hp. engine. The main bearing being the same in principle, but set in the engine base, gave much trouble from pounding on the quarter boxes and the slightest adjustment was usually followed by heating and on hot days in summer it was almost impossible to keep this bearing cool.

Requests were made to have the bearing rebabbited, but the management stated that it had been rebabbited less than 2 yr. before. After repeated efforts, however, the order was given and mechanics took out the boxes to rebabbit them. It is hard to tell who was to blame for their condition, but evidently the mechanics who had previously made repairs were much at fault. The engineer immediately resigned and a new engineer took his place, and the engine was run with the main bearing, Fig. 1, in this condition, S being the lower portion of the housing, C the cap, E the lower babbited portion of the box, G the shaft, B, B the quarter boxes, and the shaded portion, A, A, the wedges, which are adjusted by the nuts 1, 2, 3, 4.

It is seen that the end of the bolt extends through the nut on number 4 considerably, while number 1 nut is just flush with the top of the bolt. There was no cause for this difference in length of the two bolts except that one had been broken or the wedge was drawn up higher on one end than on the other, which proved to be the case, as the dotted line shows. In this condition, the wedge could not be drawn up any higher or tighter on number 4 bolt, and tightening on number 1 nut caused the quarter box to cant at such an angle with the length of the shaft that the bearing surface was tight only on one edge from the center of the length of the box to the end. Heating would occur very quickly if tightened too much, which was never enough to keep the boxes from pounding, and could not be tightened. Neither end of the boxes could be seen and when the cap was removed, there were no shims at the point K, but there were some shims at L. The cap was resting on the edge of the wedge at T and the end of the quarter box at y. The quarter box lacked about ⅛ in. of being down in place on one end, hence the wedge could not be drawn up even.

Figure 2 illustrates the position of wedge W on the back of the quarter box T. N, N are the holes for the adjusting (hook) bolts. At D is seen how much the quarter box lacked of being down in proper position at one end, and H shows how much the wedge was raised at the other end. This condition was due to the fact that the mechanics who had previously made the repairs had babbited the quarter box too full, and in scraping it, had scraped off too much on one end and not enough on the other, which not only prevented it from seating on one end, but it did not bear against the shaft on the other end, and because the quarter box did not fit in place without further scraping, the shims had been left out on that side—a bum job. I don't blame the engineer for quitting when he was left to run an engine in such condition that nobody could run without constant trouble, when mechanics were paid for the job which was supposed to put the engine in proper running order.

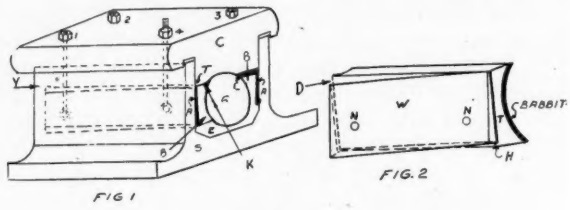


FIG. 1. MISFITTED QUARTER BOX AND WEDGE
FIG. 2. SHOWING POSITION OF WEDGE WITH QUARTER BOX

The entire box was rebabbited and bored and then scraped to allow the bottom portion to fit the shaft when the shaft was level, while the bottom of the housing was not level with the length of the shaft. When the box was assembled the nuts all drew up evenly on the ends of the bolts; there was no more trouble from pounding and after the shaft had run long enough to smooth over the babbit, there was no more heating. Shims were put in at K and L to keep the cap C from bearing on the shaft.

R. A. Cultra.

Governor Notes

The following question is often asked: "What will be the result if you add weight to the balls on a pendulum governor?" A simple answer to this is as follows: Making the balls heavier or lighter will not change the speed at which a governor of the fly-ball gravity type will assume a given position unless there is an extra weight to lift. If there is a spring resistance, the heavier the balls the farther out they will go or extend at a given speed. Heavy weight in the governor, to give power so it can move the valve gear easily and quickly, is advisable. It is not desirable to have heavy balls, as they make heavy strains on supporting links, unless they revolve slowly. When the governor runs at slow speed, there is a loss of sensitiveness to the change of speed in the engine. Using small balls, running at high speed, with an extra weight in the governor (as centerpoise) which the balls have to lift, will give a sensitive and powerful governor.

In a swinging pendulum governor, the centrifugal force and gravity are equal at one point only in its operation. The force of gravity is represented by the weight of the fly balls, and when they revolve fast enough for the centrifugal force to equal the weight, the two forces are equal. The point where the two forces are equal, or nearly so, is fixed so that when the balls are raised to the working plane by centrifugal force, the governor mechanism is cutting off the steam at its minimum point. For that reason, the same speed of governor must be maintained as an increase or decrease in engine speed hastens or delays the cutoff action beyond the proper point. If driven a little too fast, it reaches its highest plane and shuts steam all off; or if it runs too slow, it falls to its lowest plane, admitting the maximum quantity.

If extra weights are added or taken from governor, if the tension of a spring is increased or decreased, or the reach rods on a Corliss engine are changed, the speed at which a governor must be driven to be kept within its operative plane will be affected.

In most makes of pendulum governors, there is a safety pin or collar which prevents the governor from dropping so low that no steam will be admitted. When the engine is at full speed, the pin or collar should be removed. With the pin in and engine at rest, you can get steam. With the engine running, the pin must be out; then, if the governor belt breaks, the governor will drop down low enough so that the safety cam will hold crab claw from hooking on.

The oil should be kept wiped off near the governor belt; if it is not, engine may run away, due to belt slipping.

W. N. L.

Testing Condenser Tubes

SEVERAL years ago, while an operating engineer at the Lafayette Power Plant of the Ft. Wayne & Northern Indiana Traction Co., we found it necessary to remove all the tubes from a Wheeler surface condenser, in order to patch up the tube sheet.

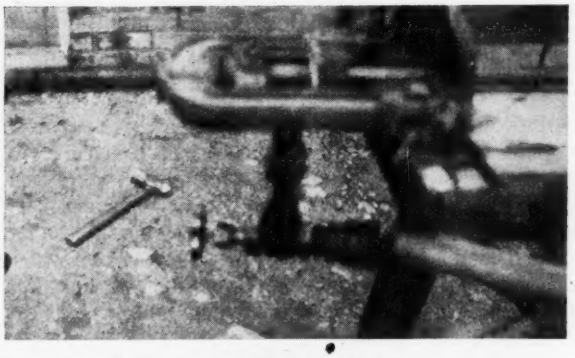


FIG. 1. VISE USED IN TESTING TUBES

Being doubtful about the tubes, we decided to test them and I rigged up a bench and a pipe vise as in the photos. We removed both jaws of the vise and drilled a hole through the bottom of it large enough to slip a tube through. Then we mounted the vise flatwise on one end of the bench, and then proceeded to screw a plug in one end of a ½-in. tee and a ½ by 2½-in. nipple in the other, the latter being turned down to fit snugly in a tube. A piece of an old soft rubber pump valve was slipped over the nipple to act as a gasket for the tube. The plug in the tee was clamped in the upper jaw holder of the vise. A water line was run to the tee with a throttle valve and also a pet cock for a drain.

At the far end of the bench a block of wood was bolted with another gasket of pump valve rubber. Nails were driven in the top of the bench to act as guides for the tube and to prevent buckling. By means of the screw of the vise we were able to press tubes tightly between the gaskets, and then to apply 60 lb. water pressure which quickly found any cracks or holes in tubes.

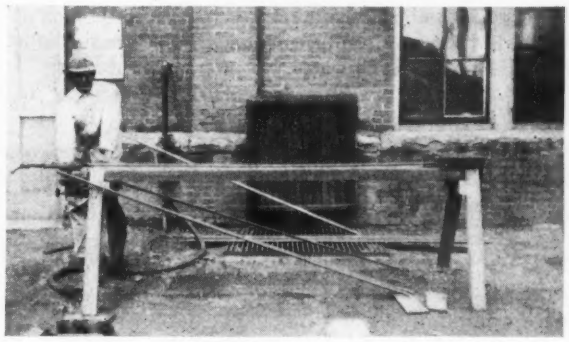


FIG. 2. TESTING A CONDENSER TUBE

We found over 200 leaky tubes out of 784, and were able to braze all of them and after retesting, use them all. At that time, new tubes could not be gotten, and as we had no further leaks after assembling condenser, and for several years afterward, the device sure paid for itself.

V. H. Cox.

Strengthening Pipe Columns

IN THE OCT. 1 issue of Power Plant Engineering is a description of an attempt to reinforce pipe columns by filling them with concrete. Anybody harboring the hope that such a method is worth the cost is deluding himself.

The pipe was filled through a hole near the top and the concrete is consequently not in bearing. Even if it were filled to the top, the concrete would shrink and there would still be no bearing; and any compressive stress carried by the concrete must be transmitted from the pipe to the concrete by the bond, or adhesion, of the concrete to the pipe.

In the pipe under consideration, the bond, because of the probable scaly condition of the surface, is slight. Assuming, however, that the bond is sufficient to develop the strength of the concrete in compression, and that the latter value is 500 lb. per sq. in., then the capacity of the concrete is about 14,000 lb.

The factor that governs the strength of a column, however, is resistance to flexure. If the concrete-filled pipe columns were analyzed as strictly reinforced concrete columns, there would be found more steel than the concrete could stress; and should these columns be stressed to the capacity of the steel, the bond of the concrete to the steel would be destroyed and flexure would cause the concrete to crack and the net result would be the same as if the columns were filled with sand.

It was not stated what was the length of the columns under discussion but it was probably not less than 10 ft.

A 6-in. standard pipe 10 ft. long used as a column will safely carry a load of 34 tons.

Should it be necessary to reinforce a pipe column that cannot, for reasons of clearance, be braced, it could be "looped," that is, surrounded with a heavy wire coil of close pitch, which coil is wired to a number of vertical rods and the whole boxed up and concreted. This, of course, would greatly increase the size of the column.

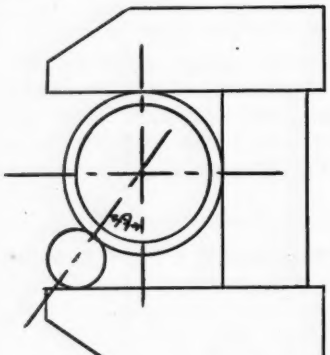
A satisfactory method of strengthening a pipe column would be to split a pipe of the next larger size (the extra-heavy weight would be a close fit), through-bolt it thoroughly and weld the two halves together. Full end-bearing may then be had by shimming and welding.

One serious objection to reinforcing pipe columns as described is the cost; replacement with a column of adequate size would be cheaper.

C. A. SANDSTROM.

An Improvised Pipe Wrench

IN THE Sept. 15 issue appears an article by M. A. Saller, entitled "Improvised Pipe Wrench." I did not believe it would work, but to be sure tried it, not only with a sharp-threaded bolt but with a flat file, which is hard and would bite on the pipe if anything would; it proved a failure.



AN IMPROVISED PIPE WRENCH AS SUGGESTED BY H. D. FISHER

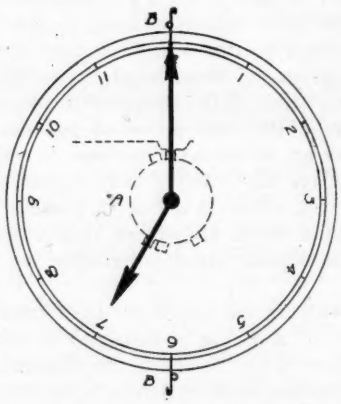
A monkey wrench can be used as a pipe wrench with either a file or a bolt if it is used as shown in the sketch and angle A is made less than the angle of friction of the pipe and bolt so that the pipe and bolt grip and the bolt tends to be rolled into the jaw. A round or flat file may be substituted, as they take a better bite on the pipe, and angle A need not be as small as with a bolt, so that the spring of the wrench can be taken up with a less nice adjustment of the opening of the jaw.

H. D. FISHER.

A Memory Jogger

THE ARTICLE entitled "A Whistle Time Reminder," which was published in the Aug. 15 issue, calls to mind some of the troubles which I have encountered in forgetting to blow the whistle until it was too late.

As a memory jogger, I fitted a clock to remind me when this duty should be done. I put a small disk on the hour hand spindle back of the dial with teeth on it at 7:00, 7:30, 12:00, 12:30 and 5:30 as shown at A with a light spring that would touch the teeth at that



CLOCK FITTED WITH CONTACTS TO ANNOUNCE TIME FOR BLOWING WHISTLE

time. I then made a spring out of fine wire as at B and connected it to the dial so that the minute hand would just touch it on the hour and half hour positions. After running wires to a bell in the fireroom and connecting up three dry batteries, my troubles were over.

R. B. R.

Record Hydroelectric Operation

I HAVE READ with interest of the 126-day run of V. C. Wood's 875-kw., 600-r.p.m., 170-ft. head hydroelectric unit in a recent issue of Power Plant Engineering and it goes without saying that such a run is a highly creditable performance.

We have, in our Oroya station three 3000-kw., 300-r.p.m. generators direct-connected to waterwheels operating under a head of 700 ft. No. 2 unit ran from Feb. 2, 1919, to July 13, 1919. No. 1 unit has run from April 11, 1920, to date, Sept. 23, and I believe that it will not be shut down for at least two or three weeks yet—barring accidents, of course.

A. L. CONWELL,
Cerro de Pasco Copper Corp.,
Oroya, Peru.

THE SMALL SON of a well-known electrical engineer is more familiar with the appliances of modern civilization than with the small things of nature, and when visiting the country unhesitatingly picked up a hornet to inspect its mechanism more closely. When his father hurried out to discover the cause of the commotion which immediately broke the peace of the summer day, the little lad was ruefully sucking a thumb, while tears streamed down his face.

"Why, what's the trouble?" he was asked.

"It was that bug," he managed to explain between sobs. "I think his wirin' is defective. I touched him and he wasn't insulated at all."—Philadelphia Ledger.

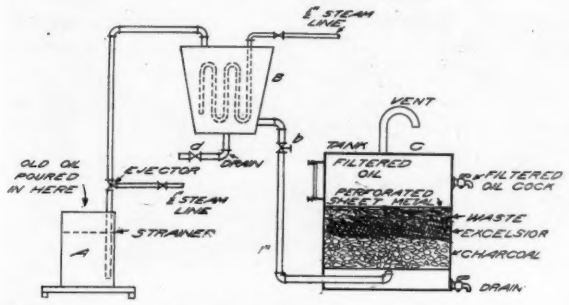
THE SMALLEST known electric motor in the world was recently exhibited at the Foundry Convention. Its length is 19/64 in.; its height 11/64 in., and it weighs 5½ gr. It runs on a small flashlight battery.—Compressed Air Magazine.

An Easily Made Oil Filter

A SIMPLE, practical and successful oil filter is shown in the accompanying illustration. The used oils are put into can A through the strainer. The oil is then ejected by a steam jet into can B, where it is heated and allowed to settle. After the heaviest particles have settled to the bottom, oil-valve b is opened between tank B and tank C. The oil then passes up through the water, charcoal, cotton-weed excelsior, and cotton-waste. By this time, it becomes fairly clean and can be drawn out at the top faucet and used.

The steam jet pump is used in this filter in order thoroughly to heat and mix the oils filtered. The jet of steam has a tendency to break up the oil and the dirt will settle quicker. The water and dirt can be drawn off through drain d.

The charcoal will catch most of the carbon and grit from the oil. It then loses some of its foreign matter as it passes through the excelsior and cotton waste. The advantage of filtering the oil up through the filtering material rather than down is that the heavier particles have a tendency to settle down and require very little friction to hold them back in the filtering material. If



DETAILS OF OIL FILTER AND STRAINER

the oil is filtered down through the filtering material, and especially through sand and ashes, there is a chance of getting grit and dirt out with the filtered oil.

A gage glass should not be used that would bypass the oil around the filtering material. The oil should be distributed about the charcoal in order that the oil will come in contact with as much surface as possible.

With this filter any heavy oil such as Diesel crankcase oil can be mixed with any light oil, such as old transformer oil, and a good lubricating oil obtained.

Engineers of limited experience hesitate to filter these used oils for fear the filtered oil may not be usable, and also, because they know of no practical way of testing the filtered oil.

A very simple way of testing an unused oil is actually to try it out in the bearings. First insert a thermometer in the bearing and obtain the running temperature of the bearing while using a known oil. Then thoroughly drain the bearing and fill with the filtered oil to be tried. Care should be taken that the bearing does not get too hot. If the temperature of the bearing does not rise after a good test is made, then the filtered oil may be used, yet always using good judgment as to the importance of the bearing in which it is used.

The used Diesel crankcase oil and old transformer oil are mixed and used in slow-speed bearings and this mixture is giving good results. The filtered turbine oils are used in the high-speed motor bearings. All heavy, dirty oils are filtered in the filter shown. All turbine, ammonia, and engine oils are filtered in a smaller filter made for these oils. This company is saving from 30 to 50 per cent of its lubricating oils. W. A. DARTER.

Use of Instruments and Measuring Apparatus in the Power Plant

WE HEREWITH cite you one instance of a neat saving due solely to installing apparatus showing what you are doing.

We commenced using natural gas in a gas engine doing 125 to 150 hp. work seven yr. ago. At first, we took the gas from the general supply line; but later we installed an individual meter for the engine. We found that we were using 30,000 cu. ft. per 10-hr. day.

After considerable experimenting, we got the daily consumption down to 8000 to 9000 per day. After a considerable increase in load, the daily consumption has risen only to 11,000 ft. Without the meter, we should in all probability still be using the 30,000 ft. per day. The extra 20,000 per day for seven yr. of 253 days per year would, with gas at 35c per thousand amount to about $12,000. Some saving! Also a remarkable example of efficiency maintained over a long period of time.

We hate to admit it, but neither rings nor pistons have been out of the cylinders in 9 yr., neither has the rod packing between the two cylinders ever been out. The valves are ground regularly and the engine is well taken care of and delivers power with about the same reliability that a steam engine does.

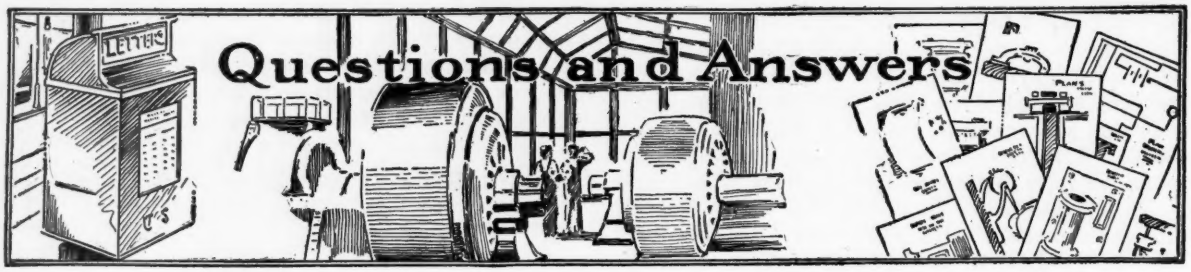
We do one thing that might help those who are having trouble with the piston pins of their gas engines. We have a 3½-in. blast pipe from the blast main blowing air into the open end of the trunk piston. We set great store by this. It carries the heat away rapidly, keeping the temperature down to a point where the oil, which is a fairly heavy cylinder oil, lubricates the pin in a satisfactory manner.

It's the B.t.u. that make the engines go. Last winter we ran out of natural gas of about 1100 heat value and substituted city gas of 650 B.t.u. value. The cubic feet used per day increased in inverse proportion to the reduced number of heat units per cubic feet.

It would be interesting to know how many cubic feet per day we used of producer gas of 120 to 140 B.t.u. per cubic foot, probably in a like proportion.

J. O. BENEFIEL.

U. S. CIVIL SERVICE COMMISSION announces examinations for Senior Engineer, Grade 2, Civil, Electrical, Mechanical, Signal, Structural, Telegraph and Telephone, to fill vacancies in the Interstate Commerce Commission, under the act providing for the valuation of the property of common carriers, at $2100 to $2700 a year, and vacancies in positions requiring similar qualifications, at these or higher or lower entrance salaries. Appointees at annual compensation of $2500 or less, whose services are satisfactory, may be allowed the increase granted by Congress of $20 a month. On account of the needs of the service, applications will be received until further notice. Apply for Form 1312, stating the title of the examination desired.



Wiring Problems

GIVE the formula for finding the area of a conductor when the diameter is known.

2. Ten lamps are located 100 ft. from the cabinet. What size wire should be used if 2-v. drop is to be allowed? Each lamp takes half an ampere.

3. If 14 lamps requiring 2 amp. each are located 125 ft. from the cabinet and there is a drop of 2 v. on the line, what size wire is needed?

4. What is the weight of 1500 ft. of No. 00 wire?

J. M.

ANSWERS

IT ALL DEPENDS upon the term in which you desire to express the sectional area of the conductors. If you are desiring to express it in inches, then in order to determine the area in square inches, you would square the diameter and multiply the product by 0.7854. On the other hand, if you desire to express the sectional area in circular mils, you would merely square the diameter in mils.

2. The following formula may be employed to solve both your second and third problems:

$$d^2 = \text{cir. mils} = \frac{21.6\ l\ I}{e}$$

Where l is the distance of transmission in feet, I is the current flow in amperes, and e is the voltage drop expressed in volts.

Substituting the values you have given, we, therefore, have

$$d^2 = \frac{21.6 \times 100 \times 5}{2} = 21.6 \times 250 = 5400 \text{ cir. mils.}$$

This would require No. 12 B. & S. wire.

3. Again employing the foregoing formula and substituting values you have given in this problem, we have

$$d^2 = \frac{21.6 \times 125 \times 28}{2} = 21.6 \times 125 \times 14 = 37{,}800 \text{ cir. mils.}$$

For this you would, therefore, have to employ a No. 4 B. & S. wire.

4. No. 00 copper wire has a weight of about 402.8 lb. per 1000 ft. of length, 1500 ft., or 1½ thousand, would, therefore, weigh 1½ × 402.8, or 604.2 lb.

Setting for Dry Back Marine Boiler

I HAVE a 150-hp. marine boiler to install and with it an American stoker, all second-hand, but in good condition. The company from whom we bought the outfit stated that there would be no need of any brickwork inside or outside of it, but others have advised me that it requires both a firebrick lining and wall around the combustion chamber. What brickwork is required for this type of boiler? I intend building up a brickwall around the back combustion space as shown on the sketch, and an arch resting on the angle irons in the combustion chamber. Will we need to line the furnace with firebrick?

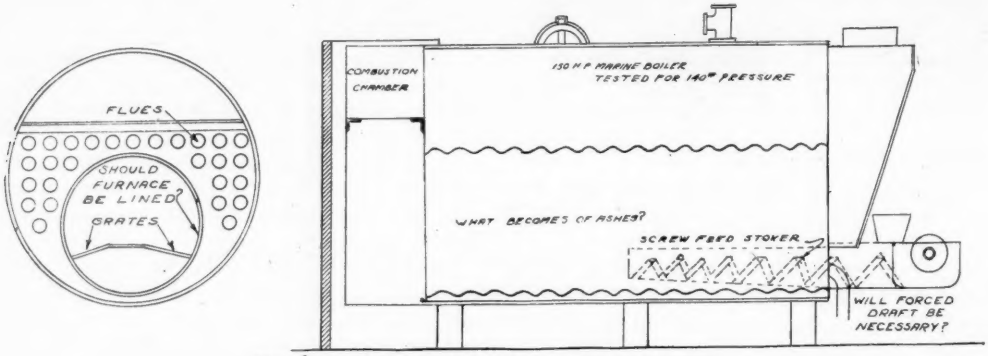


FIG. 1. SECTIONS OF BOILER TO BE INSTALLED

What becomes of the ash and clinkers? Will they not fall over the end of the stoker if no bridgewall is provided?

Will we need a fan for forced draft? A. M. A.

A. The marine boiler which you have is known as the dry back type; it is a self-contained unit and does not require an outer brick setting other than a good foundation to support it. It will be necessary, however, to line the back combustion space with firebrick and provide a back arch and a low bridgewall.

At the rear end of the boiler there is a plate to which an angle iron is attached and without the lining this entire plate will, within a short time, completely burn away. As you can readily realize, the heat from the

furnace will be quite intense at this point and as there is nothing to carry this heat away, the metal is bound to corrode rapidly.

In regard to the furnace itself, with the type of stoker which you have installed, there is no need whatever of a brick lining. If your furnace was handfired and the smoke ordinances of your city are rigid, it may then be necessary to line the furnace part way so as to insure smokeless combustion, but with the underfeed type of stoker, you should have no difficulty with smoke.

As you suggest, there should be a low bridgewall at the end of the stoker to prevent ashes from accumulating at the back of the furnace. The principle of operation of this type of stoker is that as the green coal comes in at the bottom of the trough, it is pushed up into the firebed and as it rises the volatile combustible matter in the coal is driven off and ignited as it passes through the incandescent coals at the top of the bed. The burning coal accumulates over the center of the trough and falls over to the sides of the furnace upon grates where the combustion is completed and through which the ash drops to the ash pit.

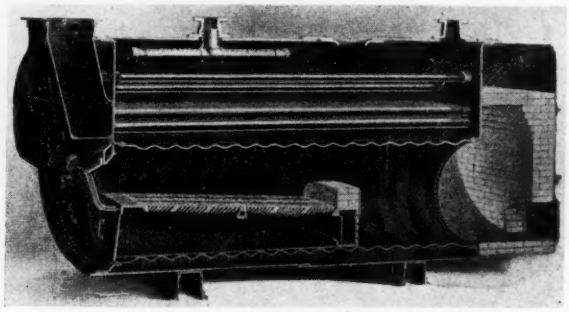


FIG. 2. VIEW OF STANDARD DRY BACK SCOTCH MARINE BOILER SHOWING BRICKWORK REQUIRED

The grates may be cleaned as with any handfired furnace with grates of similar type.

To prevent radiation it is customary to cover the entire boiler shell with a good insulating covering.

With this type of furnace, it will be necessary for you to use forced draft as the resistance of the fuel bed is too high for running the coal with natural draft alone.

Heating a Wash Room

I AM ABOUT to install a heating system and water supply in a wash house at our plant that will accommodate 300 men and would like some information on the following:

How many feet of 1¼-in. pipe would be required to heat this building 29 by 36 by 10 ft., which has tile walls and tin roof, 16 windows 12 by 36 in., two doors 3 by 7 ft.?

Could a 6-in. pipe be used for a water heater?

H. L. F.

A. In submitting your problem on heat, you have not given us all the data which is necessary.

We will assume, for the sake of example, that the temperature desired inside of the building is 65 deg. and that the average minimum outside temperature is 10 deg. below zero. We will assume also that the walls are of tile, plastered on both sides.

The area of the walls, ceiling, doors and windows must first be figured, each separately:

Area of ceiling $= 29 \times 36 = 1044$ sq. ft.
Area of windows $= 16 \times 1 \times 3 = 48$ sq. ft.
Area of doors $= 2 \times 3 \times 7 = 42$ sq. ft.
Area of walls $= 10\,(29 + 29 + 36 + 36) - (48 + 42) = 1210$ sq. ft.

The radiation loss through each one of these types of surface is figured by means of the following formula:

$$L = A \times K\,(t_1 - t_2)$$

where L = heat loss in B.t.u. per hour
A = area of radiating surface
K = A coefficient depending on character of material in radiating surface (for fireproof tile, plaster on both sides, 0.30; for glass 1.05; for wood doors, 1-in. thick, 0.48; for ceilings, no floor above, 0.50).
t_1 = inside temperature.
t_2 = outside temperature.

Substituting:

$1044 \times 0.5 \times 75 = 39{,}150$ B.t.u. loss through ceiling
$48 \times 1.05 \times 75 = 3{,}780$ B.t.u. loss through windows
$42 \times 0.48 \times 75 = 1{,}512$ B.t.u. loss through doors
$1210 \times 0.30 \times 75 = 27{,}210$ B.t.u. loss through walls

Total loss, 71,652 B.t.u. per hr. by radiation.
Add 50 per cent for changes of air... 35,826

107,478 B.t.u.
Add 10 per cent if building is in exposed situation.. 10,748

Total heat loss to be supplied by radiation .....118,226 B.t.u.

The necessary amount of pipe required to furnish heat for this room is found by means of the following formula:

$$R = \frac{H}{K\,(t_3 - t_4)}$$

where H = B.t.u. necessary to heat room,
K = a coefficient (1.8 B.t.u. per sq. ft. radiating surface)
t_3 = temperature of steam (240 deg. at 10 lb. gage)
t_4 = temperature of air (65 deg.)
R = square feet of radiation required.

Substituting:

$$\frac{118{,}226}{1.8\,(240 - 65)} = \frac{118{,}226}{315} = 375.3 \text{ sq. ft.}$$

One foot of 1¼-in. pipe contains 0.435 sq. ft. of surface. Dividing 375.3 by 0.435 gives 863 lineal ft. of 1¼-in. pipe required.

In regard to the pressure to be used in heating this building, we would suggest that you carry about 10 lb. on your heat mains. This would give a temperature of 240 deg. in the steam. We would advise that the returns be trapped and discharged back into your boiler.

The 6-in. pipe which you desire to use for your hot water tank is hardly of sufficient size to supply enough

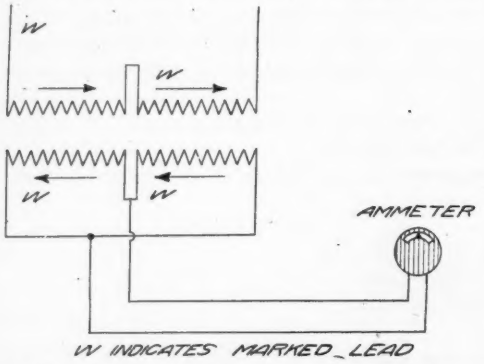
water for 300 men. If you use 30 ft. of 1¼-in. pipe as a heating column placed inside of the 6-in. pipe and supplying steam at 100 lb. pressure, we figure that you can heat about 2 gal. per minute from 35 deg. to 150 deg. The better plan would be to secure a tank having sufficient capacity, which can be heated before the rush period and will maintain a fairly even temperature in times of greatest demand.

Checking Polarity of Current Transformers

WILL you kindly inform me how properly to check the polarity of current transformers?

READER.

A. One way of checking the polarity of current transformers is shown in the accompanying illustration. The two transformers are connected in series, both on primary and secondary sides with the ammeter connected as indicated. If the polarity of the transformers is the same, the ammeter will read the difference of the secondary currents. If the two transformers are of opposite polarity, the instrument will indicate the sum



SCHEME OF CONNECTIONS FOR CHECKING THE POLARITY OF CURRENT TRANSFORMERS

of the secondary currents. Knowing the value of the primary current and the nominal ratio of transformation of the two transformers, it is easy to figure the secondary currents closely enough for this check.

WESTINGHOUSE ELECTRIC & MFG. CO.,
BY EARLE C. SOUDER.

Wants Less Wattless Current

KINDLY ANSWER these questions for me.

1. If you have an inductive reactance of 200 ohms in a circuit and a capacity reactance of 25 ohms, what will be the resultant reactive effect in ohms?

2. If the maximum pressure of an a. c. circuit is 180 v., what is the actual voltage?

3. If you know the reactance and the resistance of a circuit, how would you find the impedance?

4. What would you do to improve a wattless current?

5. If induction motors are underloaded, what effect has it on the current? What can you do to improve this?

J. M.

ANSWERS

AN INDUCTIVE reactance of 200 ohms and an inductive capacity of 25 ohms will produce a resultant reactance of 175 ohms.

2. To find the average voltage of a circuit: A voltage curve is a sine curve whose area is 2 times the value of the maximum electromotive force. The length of one lobe of this curve is 3.1416 so that the average voltage is

$$\frac{2\,E}{3.1416} = \frac{2 \times 180}{3.1416} = 114.5 \text{ volts.}$$

Effective voltage $= 0.707 \times 180$ v. $= 127.3$ v.

3. The impedance of a circuit is equal to the square root of the sum of the resistance squared and the inductive reactance, X_1, minus the capacity reactance, X_2, squared

$$Z = \sqrt{R^2 + (X_1 - X_2)^2}$$

4. A wattless current is one that does no work and is equal to one minus the power factor times the applied volt-amperes. To reduce this current, increase the power factor.

5. An underloaded induction motor will have no effect on the current; it will, however, lower the power factor. This condition may be remedied by putting more of your load on this motor.

Efficiency of Combustion

WILL YOU answer the following questions for me?

1. How many pounds of water at 195 deg. can be changed to steam at 85 lb. gage by the combustion of one pound of hydrogen assuming 3 per cent lost?

2. What is the maximum port opening on this valve: port, 2½ × 21 in.; valve travel, 6½ in.; lap, 1⅜ in.?

3. What per cent of the heat of the fuel is utilized when 2½ lb. coal are required per horsepower; coal 13,650 B.t.u. per pound?

4. What is the actual and equivalent evaporation per pound of coal and combustible?

Water evaporated	290,500 lb.
Coal burned	39,000 lb.
Ash	15 per cent
Feed water	100 deg. F.
Steam pressure	114.7 lb. abs.

H. W. B.

ANSWERS

ONE POUND of hydrogen burning to water gives up 62,000 B.t.u. gross. This is not all available, however. Nine pounds of water are produced, which must be heated to the temperature of the steam at 85 lb. gage. Assuming 60 deg. F. as the room temperature, this will amount to 1205 — 28 = 1177 B.t.u. per pound or 10,593 B.t.u.; 62,000 — 10,593 = 51,407 B.t.u. available. Heat required to change water at 195 deg. to saturated steam at 85 lb. gage is 1023.3 B.t.u.; 51,407 ÷ 1023.3 = 50.23 lb. of water which can be evaporated under the foregoing conditions by the combustion of one pound of hydrogen.

2. With a valve port 2½ by 21 in., valve travel 6½ in. and lap 1⅜ in., the maximum port opening will be 1⅞ in. or 39⅜ sq. in.

3. One horsepower-hour = 2545 B.t.u.; 2½ lb. coal at 13,650 = 34,125 B.t.u. Efficiency = 2545 ÷ 34,125 = 7.46 per cent.

Actual evaporation per pound of coal

$$= \frac{290{,}500}{39{,}000} = 7.44 \text{ lb. water per lb. coal.}$$

Evaporation from and at 212 deg. per lb. coal.

$$= 7.44 \times \frac{H - Q_2}{970.4}$$

$$= 7.44 \frac{1188.8 - 100 + 32}{970.4} = 8.60 \text{ lb. water per lb. coal.}$$

Actual evaporation per lb. combustible $= 7.44 \div 0.85 = 8.74$ lb. water per lb. combustible.

Evaporation from and at 212 deg. per lb. combustible $= 8.60 \div 85 = 10.12$ lb. water per lb. combustible.

The Vacuum Breaker

I WOULD LIKE some help on these questions.

1. How can the thickness of a pitted section of boiler shell be measured?

2. Why are a number of small valves used on a hydraulic pump instead of one large valve?

3. What is a vacuum breaker and where and for what purpose is it used? W. S.

ANSWERS

TO FIND the thickness of a pitted boiler plate, drill a hole where the pitting is deepest and measure through with a caliper rule, or else lay a straight edge along the surface and measure the depth of the pit. Subtract this figure from the nominal thickness and the result will be the thickness of the pitted section.

2. A number of small valves are used on water pumps instead of one large one because the slip is lessened and each one is cheaply removed in case of accident or wear.

3. A vacuum breaker is a valve located in the condenser chamber of a condenser. If for any reason, such as accidental stoppage of air pumps, the water rises in this chamber it raises a float valve and allows an inrush of air to break the vacuum, thus preventing further suction of water into the condenser and consequent flooding of the engine.

Comparing Barometer Readings

WE HAVE BEEN trying to make a mercurial barometer and have not succeeded in getting it closer than within 0.5 in. of an aneroid barometer which was recently compared with a government standard.

We are situated on Lake Superior (602 ft. above sea level) and have been thinking that the aneroid barometer might be calibrated to give a sea-level reading. Can you tell us whether or not this is so and how much difference in pressure a difference of 602 ft. in altitude would make?

Any information you could give on the making of a barometer (mercurial) would be appreciated.

H. G. E.

A. We have your letter of recent date, in which you state that you have had difficulty in making a mercurial barometer. It is possible that, as you suggest, the aneroid barometer may have been calibrated for use at sea level, as the difference in pressure between an altitude of 600 ft. and sea level would amount to about 0.6 in. Air pressure decreases about one-half pound for 1 in. per thousand feet height.

The simplest form of mercurial barometer consists of a tube about 30 in. long closed at one end filled full of pure mercury. The lower end is inserted in a cup or vessel containing mercury of such depth as to bring the difference in level of the mercury in the cup and that in the tube to 30 in. at sea level.

In calibrating the other figures, it is not sufficient merely to measure off the inches downward from the 30 as the actual reading is the difference in the height of the mercury in the column and that in the cup, and not merely the height of the mercury in the column. We would suggest further that you heat the mercury after it has been placed in the glass tube sufficiently to expel all air.

Compression Pressure in a Diesel Engine

I WOULD LIKE to obtain a formula for figuring theoretically the compression pressure in a gas or Diesel engine; for example, an engine 20 by 20 in. and 2½ in. clearance. H. P. D.

A. The pressure to which gas is compressed in an internal combustion or Diesel engine depends upon the compression ratio; i. e., the ratio of the total volume to the clearance volume; the intake pressure; and the kind of compression, whether adiabatic or isothermal (adiabatic compression assumes no heat lost or gained through the cylinder walls during the process, which is not practically possible; and isothermal compression assumes heat is added or lost at such a rate that the temperatures of the gases remain the same throughout the process, which is also unattainable in this case). The compression lies somewhere between these two extremes, and without further information we can take the average. For any kind of compression, this law holds. The initial pressure times the initial volume raised to the Kth power is equal to the final pressure times the final volume raised to the Kth power.

Adiabatic expansion, $K = 1.41$;

$$P_1 V_1^{1.41} = P_2 V_2^{1.41}$$

$$P_2 = P_1 \left(\frac{V}{V}\right)^{1.41}$$

With a compression ratio $\frac{V_1}{V_2} = 9$ as your engine indicates and $P_1 = 10$ lb. abs.

$$P_2 = 10 \times 9^{1.41}$$

$$= 10 \times 22.1 = 221 \text{ lb.}$$

Isothermal compression, $K = 1$;

$$P_1 V_1 = P_2 V_2$$

$$P_2 = P_1 \frac{V_1}{V_2} = 10 \times 9 = 90 \text{ lb.}$$

The average is then equal to

$$P = \frac{221 + 90}{2} = \frac{311}{2} = 155.5 \text{ lb.}$$

ALL FIRES are the same size at their start. Every second counts, so be prepared.

POWER PLANT ENGINEERING

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Prices

During the last month, a long expected price readjustment has gained very considerable headway. Some hint of it came earlier in the drop in sugar and in wool, but the larger readjustment seems to date from Mr. Ford's widely advertised cut in prices. Various explanations have been offered for the coming of the break at this time. But the old reliable law of supply and demand is sufficient if all the facts are considered. When buyers refuse to buy either because they haven't the funds or because they think prices are too high, sellers cannot sell. The manufacturer has the choice of piling up a stock, reducing his output or lowering prices until the buyers begin buying. If some progressive manufacturers lower prices and others do not, the progressive ones get the business. We have been hearing for months that our need for goods was greater than our ability to make them; which it was explained would make demand greater than supply and maintain high prices. In the face of that, prices are falling. Evidently the demand has fallen off; people have concluded to wear old clothes, patch their shoes, eat less sugar, and overhaul the old car for another season's use.

But there is another factor, which was recently brought out by O. M. Fox, the authority on business Editors' Association of Chicago. Mr. Fox called attention to U. S. Treasury Department figures showing that in January, 1919, there was a monthly trade balance of exports over imports in favor of the United States of some $409,000,000, while for August, 1920, this balance had decreased to $65,000,000 through steady rise in imports, the exports fluctuating somewhat, but showing a steady decline only since June, 1920. Also for January, 1919, the imports were 25 per cent manufactured products or about $50,000,000 a month, while for July, 1920, they were 51 per cent manufactured products,—over $250,000,000. This means that in 20 months the domestic market for manufacturers has been cut into to the extent of $200,000,000 a month, and this tendency is steadily increasing.

If the present trend continues, in a few months imports will exceed exports. This, economists have pointed out, is a healthy condition for world affairs and must be expected. Europe owes us heavily. It has no gold with which to pay, and unless payment is made in goods,—which means a trade balance in favor of Europe,—the debt will pile up until it can never be repaid. But the fact that Europe is supplying part of our demand for goods, and will supply a still larger part, indicates that our own people must prepare to meet this competition by getting onto a more rational basis of production. Wasteful and expensive methods must be eliminated; moderate profits must be accepted; reasonable wage scales and production per hour of work must be introduced where abnormal conditions have prevailed. The industry or the establishment which is on a sound and conservative basis of production and marketing has nothing to fear. But prices have started downward, will go further, and costs for materials, labor and overhead must be adjusted to the new price scale if a producer is to continue in business.

There is plenty of business in sight. In many lines, buyers are ready to buy when the price suits them, but

there is no longer the tendency to buy at any figure for fear that prices will go higher; and the manufacturer who meets these changed conditions first gets on the basis to do business at the buyers' prices first, will get the cream of the orders.

Watching Europe

Coming to us from those countries which two years ago were exerting every resource at their command to win the World War, are the plans which they propose to put into effect for supplying their industries with power. Each country has its special problem and the engineers have evolved schemes which they feel confident will result in the most economical use of their resources. On other pages of this issue Mr. Alwyn-Schmidt outlines the most prominent schemes proposed in European countries, and a careful study of these will undoubtedly suggest ways in which different parts of our own country can make use of the natural resources immediately at hand for the economical development of power.

Already the scheme proposed in England of partially coking the coal as it comes from the mines is meeting with favor here as a method of reducing the smoke nuisance in cities, as will be noted in the report of the Smoke Prevention Association. Whether or not the scheme can be made to pay in this country where the price of coal is much lower than in England, remains to be proved. Such proof must come from engineers familiar with power plant and by-product coke plant practice.

American engineers are quite alive to the possibilities and advantages of interconnected steam and hydro-electric power plants as instanced by the proposal to establish a super power zone in the eastern part of the country, yet here the plan has not been worked on an extensive scale as it has in Germany where it is proposed to enlarge the system. No doubt the experience of European engineers along this line could be of aid in the solution of problems here.

The electrification of railroads and the development of water power sites are not new solutions to power problems in America, yet the extent to which such development can be made economically varies with changing industrial conditions. It behooves the engineer who has available a potential water power site, to attack the problem occasionally, varying the given data with the existing and prospective power and economic conditions so that he may know when the time comes to make the investment. There are, of course, many phases to this problem, all of which must be considered, and we are put on our guard by the article in this issue entitled Hydroelectric Power Developments that, where much heat is needed which can be furnished as a by-product from a steam plant, the hydraulic plant may be an expense rather than an economy. This problem is similar to that of the isolated plant vs. the central station.

The development of any industry is accomplished largely through the cut and try method. Comparatively slight changes are being made in each important power development, some prove to be impracticable and do not become standard but the majority are well planned and work substantially as was anticipated. The greater the need for economy and production, the more rapid and radical will the changes be. All Europe is today straining every resource to make up for what was lost during the four years of war and, working under difficulties which we can little appreciate, its power engineers are attempting developments with which Americans must keep in touch if we expect to compete successfully with foreign industries.

Power Plant Slogans

Store Coal in Summer.
Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Good Citizenship

Colonel C. C. Ballou, of the United States Army, who was in command of the troops in Denver, Colo., during the recent tramway strike, in a speech before the Civic and Commercial Association said: "There is a distinct relationship between good citizenship and good government. The object of government is to obtain the advantages of co-operative effort. This includes the right to work and to possess the fruits of labor, the right to rear a family and the freedom of conscience."

As enemies of good government Col. Ballou mentioned the following: The passive citizen who thinks his duty done when he pays his taxes and does not aid the government in its many problems; the selfish citizen whose whole thought is self aggrandizement; the man who devotes himself to political, or partisan ends, the citizen who delegates his powers to men who will use them for selfish ends, the reactionaries who seek to impose class government at the expense of the masses, and the radicals who are avowed and open enemies of good government.

The person who, on election day, fails to perform his first duty to his country, is unworthy of the benefits of good government and furthermore has no right to criticize the deficiencies of the government he fails to aid in correcting. The responsibility of improving government conditions rests with the citizen, and, as such, he has no moral right to shirk this responsibility.

Colonel Ballou is a strong believer in the efficacy of the schools stamping out all traits of radicalism and building up men and women that will co-operate for good government. Along this line he said: "Compulsory attendance at school, a reduction in the number of pupils taught by one teacher, and proper instruction in history of civilization would be the best method of combating the enemies of the government."

As a further commendation of Col. Ballou and his "boys," order was quickly restored and there was not a single shot fired by his men.

Convention of the Smoke Prevention Association

SMOKE INSPECTORS AND COMBUSTION EXPERTS GET TOGETHER TO DISCUSS WAYS AND MEANS OF ABATING THE NUISANCE

AFTER a period of 2 yr., this association has convened to renew acquaintances and to disseminate information as to how the problem before it could best be handled. After the usual business meeting had adjourned, the rest of the week was devoted to the presentation of papers, pertinent to the subject. Various phases of the proposition were covered, but only those relating to the technical side are mentioned here.

The first technical address of the meeting was given by Nathaniel B. Wales, on "Smoke Prevention in Stationary Plants." He dealt with the principle of surface combustion as evolved by Professor Wm. A. Bone of the University of Leeds, England. When gas or atomized oil mixed with a quantity of air sufficient for its combustion comes in contact with an incandescent refractory, surface combustion results. No flame is produced; the burning takes place in direct contact with the glowing surface. Professor Bone applies this principle to the generation of steam in a boiler. The flues of a fire-tube boiler are filled with a finely broken refractory, oil and air or gas and air are admitted at one end of the tube through suitable nozzles. The combustion is started by a spark at this point. The mixture burns with a flame until the refractory is incandescent, when surface combustion begins. On account of the excessive turbulation produced by the pieces of refractory, and the consequent reduction of the stratification of the gases, the fuel may be consumed with something closely approximating theoretical air requirements. Due to the restriction of the opening in the flue, high flue gas velocities result which increases the scrubbing action and the heat transmission. Sixty per cent of the heat of the fuel is absorbed in the first third of its passage through the flue.

Mr. Wales claims that evaporation of 21.6 lb. steam per sq. ft. of heating surface per hour have been obtained. He also claims that an overall thermal efficiency of 92 per cent burning oil has been possible in a setting that has been in constant service for six months.

Professor G. F. Gebhart of Armour Institute raised the objection that such an efficiency would be impossible with the oil ordinarily used in that the heat lost due to the evaporation of the water formed by the hydrogen in the fuel would itself amount to about 8 per cent. Mr. Wales replied that these were Prof. Bone's figures and let it stand. It is to be presumed that the high efficiency mentioned was based on the lower heat value of the fuel.

This principle cannot, of course, be used for burning coal or even powdered coal, but this condition can be simulated as closely as possible by putting brick checker work in the path of the gases in order to produce turbulation.

L. R. Pyle of the Locomotive Firebox Co. followed this discussion with an address on "Some Essentials in Smoke Prevention." His talk was not technical but concerned itself rather with the human side of the situation, with the advantages of an educational over an autocratic program, and of the necessity of co-operation between the law and the power plant operators. He also put over the thought that continuous vigilance 365 days in the year was necessary to keep up the interest, that the intermittent three months on, six off, policy of propaganda was of little or no avail. He made it clear that in order to get a man to do a thing you must make him want to do it, that one cannot successfully assume a mandatory attitude.

Thos. S. Clark of the Custodis Chimney Co. then followed with a paper "Chimneys and Chimney Draft." He took up the functions of a chimney, methods of supplying draft, resistance met with in practice, the various types of chimney construction and the problems of design. This included problems of shear, tension and compression and also bending and swaying. He discussed self-supporting and guyed steel stacks, ordinary brick and formed brick stacks, concrete stacks and fire brick liners. He also touched on wooden stacks for use in certain chemical processes. Being particularly interested in formed brick chimneys, he went into this subject to some length.

The Wednesday session opened with an address by Dr. E. Vernon Hill, chief sanitary inspector, Chicago, "A Suggested Solution of the Municipal Smoke Problem." He began by pointing out the losses due to transportation of fuel as it is practiced today. Mention was made of the leakage in transit, the cost of rehandling by the jobber and the retail dealer and the profit taken by these merchants. He spoke of the dirt nuisance due to haulage through city streets to dumping into the street and onto sidewalks and the shoveling into the residence. The low efficiency of the usual small heating plant was considered. As a remedy for this situation Dr. Hill advocated the use of what he terms the block system or central heating system. This plan is to heat a block, or several blocks for that matter, of residences by one heating plant; this plant to be operated on a no-profit basis by the members of the community. This system is in successful operation in several cities, including several sections of Chicago, Oak Park being a noteworthy example. Dr. Hill also said that he was not in favor of burning raw fuel under boilers. Instead he suggested public owned gas companies that would partially distill the coal and put the gases into the city mains, after having taken out some of the more valuable coal tar products. The residue of semi-coke from this operation should then be distributed to the community heating plants and to other industrial installations for use as fuel.

There was some discussion on his paper as to the condensation losses in pipe lines. Several successful installations were mentioned by representatives from different sections of the country.

Then followed an address by Henry Kreisinger, formerly of the Bureau of Mines on "Modern Development of Powdered Coal Burning," and a talk by H. A. Savage, of the Combustion Engineering Corp., on "Powdered Coal Practice." Mr. Kreisinger devoted himself largely to a discussion of ash disposition and the ash

nuisance in connection with powdered coal burning. He made the statement that in a certain plant where experiments were carried on, one-third of the refuse was collected at the bottom of the furnace, one-third removed from between the second and third pass, and one-third left in the furnace. Of this last third about 88 per cent was collected in a dust separator, and a portion of the rest was deposited in the breeching and base of stack so that only about 2 per cent of the refuse left the stack. This 2 per cent was, of course, composed of the very finest particles.

The structure of the ash particles came in for consideration. As the ash particles are separated from the coal in the passage through the furnace, they are fused into minute beads or globules of a glassy structure. When examined under a microscope some of these beads are translucent, some black and some white. A demonstration of what this ash looks like as it issues from the stack was made by blowing some of it into the air. A small gray cloud was formed which was dissipated almost immediately.

Mr. Savage's remarks dealt with types of installations. Several slides were shown to illustrate. Emphasis was placed upon the necessity of large combustion spaces and relatively low velocities through the combustion chamber to insure completion of combustion before the cooling surfaces are reached. Mr. Savage also made some statements as to the quality of fuel that could be burned in this manner. He said that so far as he knew, this was the only method of firing that would burn coal as high as 40 per cent ash. In the usual discussion that followed, Joseph Harrington took exception to this statement and said that he had observed certain chain grate installations burning coal containing as much as 40 per cent ash and 7 per cent sulphur with perfect satisfaction.

Professor A. C. Willard, of the University of Illinois, addressed the meeting on the subject, "Heating Boilers and Furnaces, Power Plant Design and Ventilation." He spoke first of the utility of the heat balance in locating losses. By carrying through two balances, one showing inherent losses and the other showing actual losses, any discrepancy manifests itself and steps may be taken to diminish the loss. He carried out such a balance to illustrate the point. The subject of heat losses in a building from wind blowing in through the crevices around windows and doors was given attention. This was followed by a discussion of the loss of efficiency due to air pockets in heating systems and the causes and remedies.

On Thursday morning, J. T. Antony, of the American Arch Co., presented an illustrated lecture on the "Value of Brick Arches in Smoke Prevention." As Thursday was Railroad Day, he limited his discussion to locomotive installations. He described the steam-line action of the gases passing through the furnace and the consequent stratification and how this was remedied by putting in arches to break up the flow and cause turbulation. Pictures were shown indicating how holes in the fire and patches of green coal allowed cold air streams in one case and volatile combustible on the other, to go through the furnace practically undisturbed when arches were not used. Arches are being used on all large locomotives and it is just as important that they be used on the smaller switching engines.

New Development in Damper Regulation

A NOVEL, as well as effective method of damper control by what is termed graduated action has recently been developed by the National Regulator Co. This improvement in the form of a compensating device admits of regulating the damper so as to remain in any position between full opening and full closure. In other words, the regulator may be set so as to stop the damper movement when it is half closed, three-eighths closed, one-quarter closed, etc., in fact at any portion of its travel. It furthermore attains this regulation over a widely varying range of steam pressures and the pressures between which the regulator is set to operate may be changed when desired in a few moments.

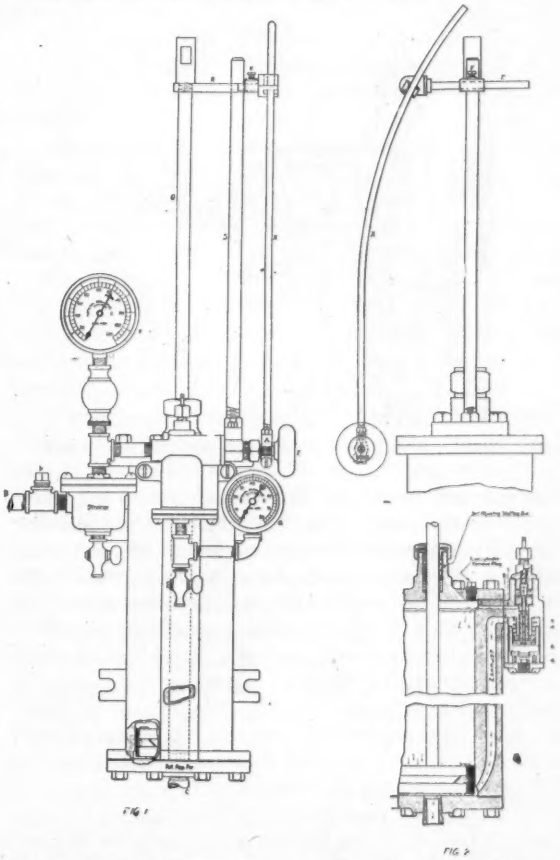


FIG. 1. DAMPER REGULATOR FITTED WITH COMPENSATING DEVICE

FIG. 2. PARTIAL SECTION THROUGH CYLINDER AND GOVERNING VALVE

The device, shown in Fig. 1, consists of an arm R, rigidly attached to the piston rod Q of the regulator proper. This arm slides upon the guide rod, S, with the travel of the piston. At the end and at right angles to the arm R is attached the rod T which is adjustable and may be fixed in any position by the set screw V. A special fitting at the end of the rod T engages the curved arm X with a sliding fit.

It will thus be evident that as the regulator piston moves up and down, the reciprocating movement is trans-

mitted to the rod T, and this, sliding on the curved arm X, translates the piston movement into a rotary motion of the adjusting wheel E.

To understand the result of this action, we must first describe the action of the regulator proper. Referring to Fig. 3, steam at boiler pressure is admitted through a strainer to the governing valve and tends to seat check valve 2, and also tends to unseat check valve 3, the opening of which is resisted by the spring of the adjusting wheel.

When the pressure increases slightly above the point at which the regulator is set, a slight pressure passing check valve 3 accumulates in chamber 5. When the pressure in this chamber reaches 4 or 5 lb., the plunger 6 will have lifted and engaged check valve 2, lifting it slightly off its seat, admitting pressure from the boiler to the cylinder through port 7, gradually forcing the piston

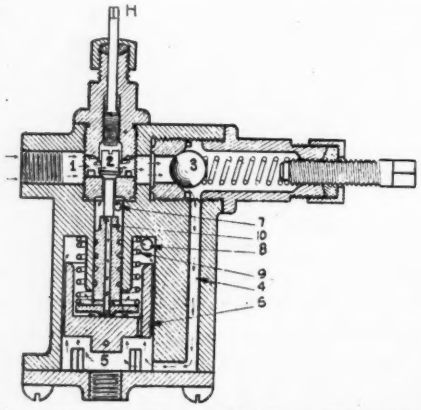


FIG. 3. CROSS SECTION THROUGH GOVERNING VALVE

downward and actuating the damper or stoker valve through the chain or cable connections. When the boiler pressure has decreased through movement of the regulator closing the damper, and steam pressure drops to the point at which the regulator is set, no more steam will pass check valve 3, consequently pressure in 5 will be broken and plunger 6 will gradually fall, allowing check 2 to seat, preventing further ingress of steam to the cylinder and uncovering port 10. The damper or valve, which must be counterweighted open, will therefore tend to return the piston, and the decreased pressure in the cylinder will exhaust through port 7, since the check valve is closed, and pass out through passage 10, through the escape port 8, to the bottom of the cylinder and out through the exhaust.

The action just described will take place with a variation in pressure of only one pound. This, however, in a great many cases is too close and regulation over a wider range of pressures is desired. This is made possible by the graduated action improvement. Let us suppose that it is desired to close the damper under a variation of 10 lb., say between 100 and 110 lb., the action will be as follows:

When the rising boiler pressure reaches 101 lb. the regulator will come into action, and the piston will start to travel downward. As it does so, however, the adjusting wheel E is automatically turned so as to increase the tension of the spring until it counteracts a pressure of 101 lb. The regulator will then stop, and the damper will be partially closed. Suppose, now, that the boiler pressure increases to 102 lb. The action will be repeated and the piston will descend until the movement of the adjusting wheel has increased the setting to 102 lb. The regulator will again stop with the damper closed a bit more. Again the pressure increases say to 105 lb. The piston descends and stops at half of its travel, due to the setting of the regulator being automatically increased to 105 lb. The damper is now half closed. And so on, the damper closing a bit more with each increment of pressure until finally at 110 lb. the damper is entirely closed.

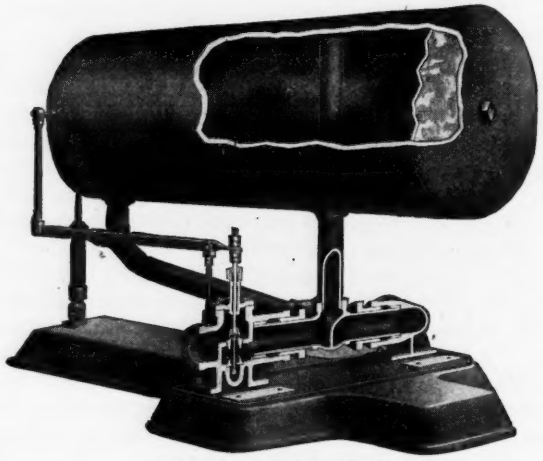
The range of pressures over which the above described action takes place is regulated by varying the position of the rod, T, with respect to the curved arm X. By turning the adjusting wheel, E, by hand, the movement of the damper may further be controlled so as to operate between half, quarter or any opening desired and full closure.

The device is positive in operation and its extreme simplicity guarantees uninterrupted service under all conditions. It is not only suitable for use in plants subject to widely fluctuating loads, but is adaptable to suit any boiler room condition, such as regulating high-pressure blowers on steady loads, etc.

Ellis Traps

STRENGTH, simplicity, effectiveness and certainty of action are among the important requirements for a trap that is to be satisfactory to users.

Features of this Ellis trap shown in the accompanying cut are that water of condensation runs into the receiver tank, 1, which, when empty, stands horizontal.



SECTION OF ELLIS TRAP

When the water overbalances a weight in the head the tank tilts and this motion opens a valve, admitting steam to the receiver. The water is forced out by the pressure, and the weight brings the tank back to the horizontal position ready for refilling.

The tank is constructed of Armco iron sheets with welded seams to withstand a hydrostatic test of 450 lb. Valve stems and fittings are monel metal with Jenkins renewable discs, and trunnion ends are faced to turn in brass bushings, so as to eliminate binding in case the trap gets out of level, with bearings nickel-plated so that

they will turn in the glands without binding when packed with sufficient pressure to prevent leakage.

Rapid tilting to open and close is secured by the position of the weight in the head. As the tank moves to open the valve, leverage of the weight is decreased giving the water greater effective movement to produce tilting. When the tank starts toward the horizontal, after being emptied, the weight leverage is increased, accelerating the closing action. Shock at the end of the movements is prevented by two springs which absorb the force of the impact.

Four types are made: the direct return operates to collect water and discharge it into the boiler, operative only when placed 4 ft. above the water line. In case the pressure in the system cannot force water to the trap in this location, the lifting type is used, usually placed on the floor of the boiler room. This lifts the water to a direct return trap by means of full boiler pressure, and the direct return trap delivers to the boiler. In case the pressure in the system is too low to force condensation from the system, the vacuum type is needed, in which a spray of cold water produces a vacuum by condensing action drawing in the water from the system. Boiler pressure is used to deliver the water to the direct return trap. When desired to collect water from a pressure line, the separating trap is used, discharging the water to a hot well or tank and preventing the escape of steam.

Each type is made in seven sizes for steam connections from ¾ in. up to 2 in. and water connections from ¾ in. up to 3 in. The capacity of direct return, lifting and vacuum traps ranges from 1800 up to 18,000 lb. of water per hour. Capacities of the separating traps vary with the working pressure, ranging from 2200 up to 18,000 lb. of water per hour at 5 lb. pressure, and from 10,000 up to 85,000 lb. per hour at 100 lb. pressure.

Augustus C. Buzby

AUGUSTUS C. BUZBY, president and founder of the Keystone Lubricating Co., died on Tuesday, Sept. 21. Mr. Buzby was born 66 yr. ago in New Jersey. He was a descendant of an old Quaker family, which settled in Burlington County, N. J., in 1640. He went to Philadelphia while a youth, and attended the Philadelphia College of Pharmacy. After his graduation from that institution, he engaged in chemistry, and subsequently organized a wholesale drug supply business, which he conducted until he founded the Keystone Lubricating Co., which is one of the largest manufacturers of lubricating oils and greases in the world. He had always made it a cardinal point to advance and promote the interests of patrons in every possible manner, and his square deal methods of business were instrumental in developing a large and important trade.

Mr. Buzby was one of the oldest members of the Manufacturers' Club and during his younger days took an active interest in the affairs of the club. He was also a member of the Philadelphia County, Pen and Pencil, Friendly Sons of St. Patrick, Terrapin Club, and other clubs and was a prominent Mason.

He was a vestryman of the Episcopal Church of the Savior. He is survived by his widow, Mrs. Florence Buzby, and four sons. His funeral took place from his late residence, 4528 Spruce Street, Philadelphia, on Friday, Sept. 24.

Although the business community will learn with regret of the death of Mr. Buzby, at the same time it is gratifying to know that his passing away will in no way affect the business of the Keystone Lubricating Co., which will be continued under the management of the surviving officials, Harold A. Buzby, vice-president and general manager; Warren F. Buzby, second vice-president and treasurer; Norman F. Buzby, secretary and export manager, and Kenneth K. Buzby, assistant treasurer, sons of the deceased, who are all conversant with every detail of the business.

Book Reviews

HANDBOOK FOR HEATING AND VENTILATING ENGINEERS, by James D. Hoffman, assisted by B. F. Raber: 476 pp., 4 by 6 in., 200 ill., 15 tables; New York, 1920; leather.

Starting with the measurement of heat and temperature, Mr. Hoffman takes the reader through the subjects of heat transfer by convection and radiation, the heat lost through walls and roofs, heat supplied by persons, lamps, gas jets, etc., and the balance to be furnished by the heating system; also the air requirements for proper ventilation and maintaining of proper humidity. He illustrates all this by application to practical problems so that the student can see just how the data is to be applied.

Two chapters are given to proper installation of furnace heating, two to hot water and steam heating, one to mechanical vacuum heating, three to mechanical warm air heating (indirect systems), one to temperature control, one to electrical heating and one to refrigeration. A final chapter is on specifications, and three appendices give tables on heating and ventilating, refrigeration and data from tests of heating apparatus.

While the treatment is necessarily condensed, it is nevertheless complete. As an example, under steam heating, space is found to consider such details as the effects of height and width of a radiator, of condition of radiator surface, and of housing in radiators on heat transmission.

Algebraic formulas are freely used to save space, but the application of formulas is illustrated so that they should present no difficulty to anybody familiar with working arithmetical problems. One chapter on district heating by hot water or steam from a central plant gives unusually complete data on the apparatus used, layout of systems, details of construction and operation and cost of heating by this method.

With the book is furnished a 50-page pamphlet of questions and problems, which makes it an easy matter to carry out a home study course on the subject, and also gives a great number of references for general reading in other books and in periodicals. Mr. Hoffman has achieved a well-planned and well-executed piece of work, and produced a book well worth a place on the desk of any engineer who has to deal with the subjects of heating and ventilation.

BLUEPRINT READING, OR INTERPRETING WORKING DRAWINGS, by E. M. Wyatt; 86 pp., 6 by 9 in.; Milwaukee, Wis., 1920.

This book undertakes to present the fundamentals of the universal trade language of mechanical drawing for the benefit of the artisans who must read, but who are not interested in writing it. It has been developed as the result of the author's experience in teaching classes of carpenters, masons, electricians, machinists, etc., the fundamentals of interpreting working drawings.

The table of contents covers the following: Kinds of Drawings; Theory of Orthographic Projection; Meaning of Various Kinds of Lines; Foreshortened Lines, Inclined Surfaces, Auxiliary Projection; Scale Drawing, Dimensions; Breaks, Representing Drawings as Broken; Sections; Bolts, Screws, Threads, Machining or Finish; Rivets—Structural Steel; Architectural Conventions; Study of a Set of House Plans; Study of the Bench Grinder.

The book is provided with 29 full-page drawings, treating mechanical objects, sections of machinery and architectural conventions, each chapter being provided with a series of questions and problems to be answered by the student.

NOTICE HAS BEEN received of the publication of two new circulars, Nos. 116 and 117, by the University of Illinois Engineering Experiment Station.

No. 116, entitled "Bituminous Coal Storage Practice," by Professor H. H. Stoek, C. W. Hippard and W. D. Langtry, is a supplement to and an extension of an earlier edition, "The Storage of Bituminous Coal" No. 6. Considerable space has been devoted to actual experience of storage piles, and where fires have occurred the causes have been carefully studied and reported on. The results of these investigations give a prospective storer of coal definite information on what to do and what to avoid in storing. This paper should be of special interest in these days of high labor costs and car shortage necessitating large storage reserves.

No. 117, "Emissivity of Heat from Various Surfaces," by V. S. Day, concerns itself principally with an investigation of the value of insulating materials usually employed in warm air house heating systems as effecting economy of operation.

Copies of these Bulletins may be had free by addressing the Experiment Station, Urbana, Ill.

News Notes

OF ALL THE countries where the safety movement has gained sway, in America alone has it been the result of a democratic movement of both employers and employes, and the greater success which the movement has achieved in this country than in others is attributed to this fact by Charles P. Tolman, the new president of the National Safety Council, who was elected at the Ninth Annual Safety Congress held in Milwaukee, Sept. 27 to Oct. 1. Mr. Tolman is chief engineer of the National Lead Co., New York City.

Other officers for the year elected at the Congress are: First vice-president, W. H. Cameron, secretary-treasurer of the Workmen's Compensation Service Bureau, New York City; second vice-president, L. A. DeBlois, manager of safety section, E. I. du Pont de Nemours & Co., Wilmington, Del.; third vice-president, W. E. Worth, assistant manager, industrial relations department, International Harvester Co., Chicago, Ill.; fourth vice-president, John A. Oartel, safety engineer, Carnegie Steel Co., Pittsburgh, Pa. The following officers of the staff at the national headquarters in Chicago were re-elected: C. W. Price, general manager; Sidney J. Williams, secretary; W. H. Frater, treasurer, and R. T. Solensten, assistant secretary.

President Tolman's statement on the contrast between the safety movement in America and Europe follows:

"There is one thing which has impressed me as particularly an essential of the safety movement, and that is that it depends entirely upon a sense of individual responsibility.

"The safety movement in Europe was largely a matter of mechanical exhibitions and an autocratic enforcement of rules. It nevertheless did good. In England, the safety movement was more paternalistic and a matter of enforcement of rules of hygiene as well as mechanical safeguarding. In America, the safety movement is noticeably a democratic movement dealing, for the greater part, with the humane consideration and with the individual himself. The safety movement, where it has succeeded largely, has so succeeded because the individual was himself made to feel the responsibility both for himself and his fellow-workers."

THE UNITED STATES DEPARTMENT of Agriculture recently became a member of the American Engineering Standards Committee. This committee is an organization originally made up of three members from each of the five founder engineering societies—American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, and the American Society for Testing Materials. The committee was later enlarged to take in three representatives each for the Army, the Navy, and the Department of Commerce. More recently organizations dealing with safety codes and with fire protection have been admitted to membership on the committee. The purpose of the American Engineering Standards Committee is to bring about the adoption of uniform and satisfactory standards in engineering work.

ANNOUNCEMENT has been made of the appointment of R. A. Bull, Pittsburgh, as consulting metallurgist for a number of prominent steel foundries grouped for the purpose of developing and perfecting higher standards in the production of steel castings. Mr. Bull will devote his entire time to preliminary research work immediately and has resigned his position as vice-president of the Duquesne Steel Foundry Co.

The members of the group include: Electric Steel Co., Chicago, Ill.; Fort Pitt Steel Castings Co., McKeesport, Pa.; Isaac G. Johnson Co., Spuyten Duyvel, N. Y.; Lebanon Steel Foundry Co., Lebanon, Pa.; Michigan Steel Castings Co., Detroit, Mich.; Sivyer Steel Castings Co., Milwaukee, Wis.

Mr. Bull is widely known in the steel castings industry as an authority in metallurgy and foundry practices, is a member of numerous technical associations and has

frequently contributed to the technical press. Since 1911 he has been a director of the American Foundrymen's Association and during 1916 and 1917 served two terms as its president. His connection with the foundry industry covers a period of over 20 yr. during which he has held important positions in foundries at St. Louis, Chicago, New York and Pittsburgh.

SECTIONS of the American Society of Mechanical Engineers have been organized on Materials Handling and on Aeronautics. Special meetings will be held, devoted to topics in which members of these sections are interested, also joint meetings with other sections on topics of common interest. It is planned to have such meetings both at the general meetings of the society and for local sections.

FEDERATED AMERICAN ENGINEERING SOCIETIES meets in Washington, Nov. 18-19. The program includes: Adoption of constitution and by-laws, election of permanent officers and organizing meeting of executive board of American Engineering Council. Seventeen organizations have joined the federation to date and it has been estimated that the membership will be considerably in excess of 60,000—the largest engineering organization in the world.

A GENERAL PLAN to co-ordinate the work of the various associations interested in changes in the executive department was set on foot Oct. 5 when John T. Pratt, former Secretary of War Stimpson, Herbert Hoover, Paul M. Warburg, M. O. Leighton and C. T. Chenery met and decided to call a meeting of representatives of all interested organizations Oct. 14. A general plan will be submitted by the national committee on governmental economy.

THE INTERSTATE COMMERCE COMMISSION issued an order Oct. 8 requiring all railroads east of Montana, Wyoming, Colorado and New Mexico to furnish coal cars to mines in preference to any other use. Former orders applied only east of Mississippi River. They have been successful in diverting coal to the Lakes region and to New England, but other sections have suffered serious shortage.

U. S. CIVIL SERVICE COMMISSION announces an examination for associate electrical engineer to fill a vacancy in the Bureau of Mines, Department of the Interior, for duty at Pittsburgh, Pa., at $2500 to $3000 a year, and vacancies in positions requiring similar qualifications at these or higher or lower salaries. Applicants must have reached their twenty-sixth birthday on the date of the examination. Age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312.

U. S. SECRETARY OF INTERIOR has announced appointment of Herbert Hoover as a member of Advisory Board associated with U. S. Geological Survey in development of plans for "superpower" designed to supply railroads, public utilities and private industry throughout eastern industrial region.

AMERICAN ENGINEERING Co. has opened a new office in the Neave Building, Cincinnati, Ohio, for the purpose of extending representation and service. M. M. Masson is in charge of this office.

WARREN WEBSTER & Co. announces the establishment of a branch office at 15 East Fayette St., Baltimore, Md., and the appointment of Louis G. Vance as Baltimore district manager.

THE MAGNOLIA METAL Co. has erected a new factory and office building at 37 Shannon St., Montreal, Canada, to which location the branch office will be moved Nov. 1.

Trade News

THE NORDBERG MANUFACTURING Co. of Milwaukee, Wis., has just completed an extension of its main machine shop and bays. The new addition, which is 200 by 180 ft., will facilitate the erection of large engines and hoists, such as the 2000-hp. Diesel oil engine and several large hoists now on order. One of the latter, known as the Mitsue hoist in Japan, will be the largest hoist ever exported. The others are for the Arizona mining field. Prior to the erection of the new addition, large castings after being machined, were placed on the erecting floor, This handicapped the erectors by limiting the available space for erecting purposes. Under the new arrangement, the machined castings will be placed in the new addition until wanted on the erecting floor. A new addition to the office building is also being rushed to completion, which will provide large private offices and more space for the drafting room.

THE USE of Link-Belt roller chain as a means of power transmission has been growing so rapidly that the Link-Belt Co. has for some time back felt it would be desirable to publish an engineering data book on the subject. Its new 78-page book, No. 257, is illustrated by photographs of roller chain drives operating motor trucks, tractors, cotton gins, industrial locomotives and other equipment, but it is more than an ordinary catalog, containing tables from which almost anyone can select the proper size of chain and sprocket wheels to result in the best driving arrangement; also other tables and engineering data of interest to those having occasion to design, locate, or figure drives, to whom will be sent a free copy of this book upon application to the executive offices of the Link-Belt Co., 910 S. Michigan Ave., Chicago, or any of its branches.

A NEW BOOK on heat-insulation, entitled "Defend Your Steam," is being distributed by the Magnesia Association of America. Its 80 pages contain a variety of valuable and interesting information upon heat and heat losses, their cause and prevention, tables and data on coal saving, the correct thickness of pipe and boiler covering for greatest economy, co-operative heating, the manufacture of 85 per cent magnesia, and a short hispipe and boiler coverings by U. S. Bureau of Mines and tory of insulation. The contents also include tests of other authorities, experiments in water soaking of coverings, examples of the re-use of old coverings on new work, chapters on depreciation under insulation, durability and efficiency under exceptional conditions as well as the full Magnesia Association specification for the

application of pipe and boiler coverings, to every form of heated surface. Tables and data are added for the use of engineers and architects in the preparation of specifications for heat insulations. This book, besides being written in an interesting, informative style, constitutes a valuable work of reference on a subject of which unfortunately little is known and less understood by the average user of steam.

FROM THE GRISCOM-RUSSELL CO., 90 West St., New York, we have received Bulletin No. 260, which discusses special features of Reilly feed water heaters and methods of installing them.

POWER TRANSMISSION MACHINERY Catalog No. 66 of The A. & F. Brown Co., Elizabethport, N. J., illustrates and gives brief points in regard to the company's turned steel shafting, bearings, friction clutches, couplings, gears, pulleys, flywheels, etc., together with price lists.

BUFFALO FORGE CO.'S Catalog No. 460, on standard pipe coil heaters, has been prepared with the view to make it useful to architects and engineers in figuring the heater requirements for fan heating and ventilating work. Tables have been elaborated so as to include all the conditions usually met with in practice and enable the user to read the values direct. To meet unusual conditions, curves giving values for various steam pressures and air velocities have been added.

A NEW mechanically operated gas producer is described in an illustrated bulletin lately received, relating to the Smith Type "G" gas producer. In addition to use in gas engines, a list is enumerated of practical uses for Smith cold clean producer gas for fuel purposes in the iron and steel industry, glass and pottery industries, chemical industry, foundries, baking food products, Portland cement manufacture, etc.

Copies of this bulletin, No. 16, will be supplied to those interested on application to the Smith Gas Engineering Co., Dayton, Ohio.

NEWLY ISSUED bulletins have been received from Warren Webster & Co., Camden, N. J., as follows: Webster Feed-Water Heaters, Bulletin 100—1; Webster letin 102; Webster-Lea Heater Meter, Bulletin 200; Steam Separators, Bulletin 301; Webster Oil Separators, Bulletin 401; Webster Sylphon Trap, Bulletin 701; Webster No. 7 Trap (for use at the outlets of steam radiators and coils at drip points on steam supply lines and risers and at the outlets of blast sections on fan coils), Bulletin 702; Webster Type N Modulation Valve, Bulletin 705—1; Webster Sylphon Attachments (for "Sylphonizing" radiator outlet valves of other makes), Bulletin 851; Webster Expansion Joints, Bulletin 1100; Webster Vacuum System of Steam Heating, Bulletin B500.

ARTHUR D. LITTLE, INC., chemists and engineers, 30 Charles River Road, Cambridge, Mass., has just announced that a limited number of copies of its monograph on "The Petroleum Outlook" are now available for distribution to bankers, brokers, manufacturers and investors free of charge on application. This work comprises an economic study of "The Petroleum Outlook" with especial reference to American fields, a large map and several charts, arranged for comparative reference, with an illuminating discussion of the status of the numerous oil fields. The text, written in popular style, deals with the geology, production history and apparent state of exhaustion of our petroleum resources and may readily be understood by any intelligent layman. It is an impartial, forceful presentation of the petroleum problem without reference to the companies or interests that own or operate in the respective sections.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.,

required by the Act of Congress of Aug. 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for Oct. 1, 1920

State of Illinois } ss.
County of Cook }

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reserve of this form, to-wit:

1. That the names and addresses of the publisher, editor, and business managers are:
Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, none.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of the stockholders owning or holding 1 per cent or more of the total amount of stock.)
Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
A. L. Rice, Chicago, Ill.
A. E. Rice, Wilmette, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)
There are none.

4. That the two paragraphs next above, giving the names of owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest, direct or indirect, in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is ..... (This information is required from daily publications only.)

Chas. S. Clarke, Secretary.

Sworn to and subscribed before me this 22d day of September, 1920. Robt. R. Greig,

(SEAL) (My commission expires Oct. 26, 1923.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.